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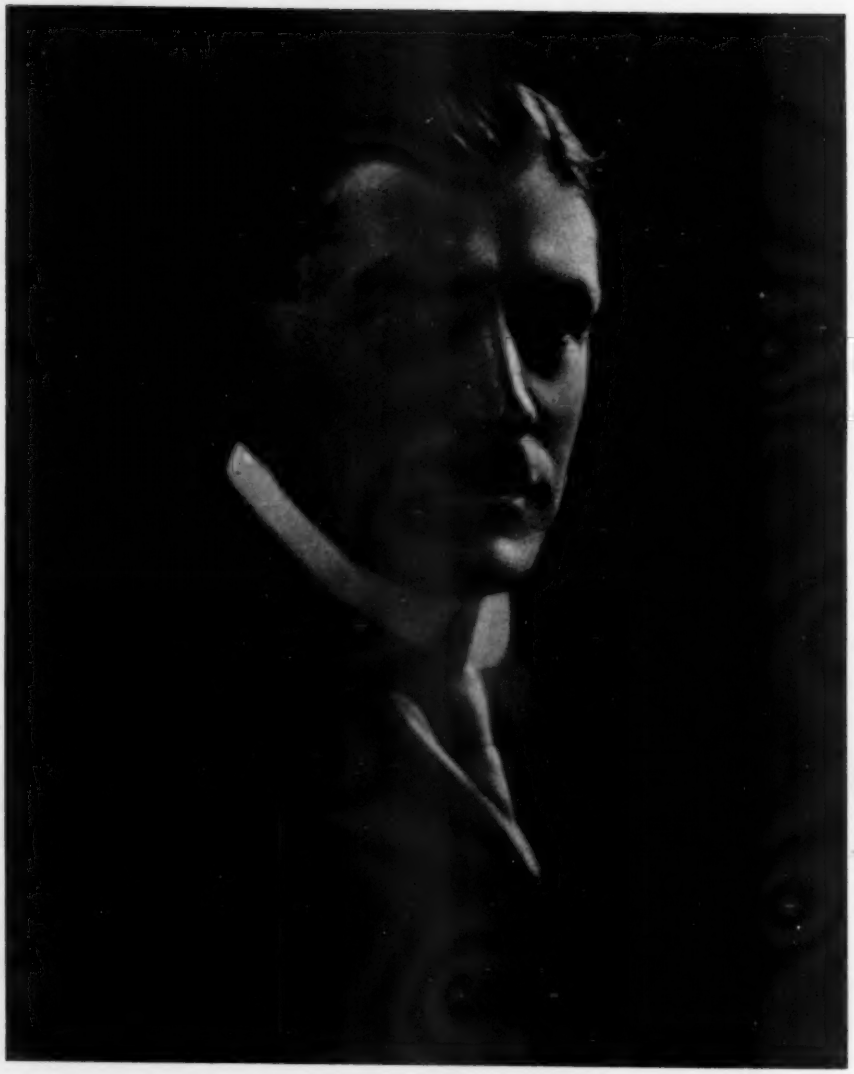

Russell B. Boggs

THE AMERICAN JOURNAL OF ROENTGENOLOGY

VOL. IX [NEW SERIES] OCTOBER, 1922 No. 10

ROENTGEN STUDIES OF THE THORACES OF THE STILLBORN AND NEWBORN*

BY WM. A. EVANS, M.D.

DETROIT, MICHIGAN

THE FUTILITY OF INSUFFLATION IN ASPHYXIA NEONATORUM

MY interest in chest work has led me, during the past year, to undertake a study of the thorax of the stillborn and newborn. Special attention was directed to the newborn with respiratory disorders. The findings in this type of case were of definite clinical interest, and also, we believe, of considerable practical value.

A review of the literature of the past three years on the subject of asphyxia neonatorum indicates that very little work has been done. The reason given for the neglect of this field is that neither the obstetrician nor the pediatrician considers this field his province, and each is apparently waiting for the other to solve the problems pertaining to the subject. Von Reuss, of Vienna, in his book on the "Diseases of the Newborn," adopted the following classification:

(*a*) Stillborn—When there is no heart-beat.

(*b*) Asphyxia—Two types:

1. Asphyxia pallida—heart-beats but no respiration.
2. Heart-beats but respiration impaired.

We believed that *x*-ray study of the chest would give valuable information, and with this in mind, we undertook the examination of newborn children, using the plate method.

A knowledge of the embryology and histology, as well as the gross anatomy of the chest, is necessary for intelligent interpretation of such chest plates. There is a surprising lack of knowledge of the condition of the lungs during fetal life, the usual conception being far from the facts in the case.

To review briefly the development of the respiratory tract: The epithelium is developed from the entoderm and the connective tissue portions from the mesoderm. The first differentiation of the respiratory system appears as a dipping down of the entoderm by one or possibly two invaginations of the floor of the pre-existing pharynx. This tubule divides into two branches. These again divide, two from the left, and three from the right, corresponding with the lobes of the lung. By repeated subdivisions of these tubules, the entire bronchial system is formed. Up to six months this process goes on, the development being that of a compound alveolar gland. The last structures to develop are the respiratory divisions of the bronchi with their alveolar passages and alveoli, this appearance of the alveoli being wholly characteristic of lung. The epithelium of the alveoli is at first entirely of the fetal cell type, the lining cells are polyhedral or rounded, and project from the walls. Opinions as to when the cells change to the flat type vary. Certainly, most of the change occurs immediately after birth.

In fetal life the lung entirely fills the thorax, but is completely atelectatic. All of the plates which we obtained of the

* Read at the Midwinter Meeting of the Central Section of THE AMERICAN ROENTGEN RAY SOCIETY, Chicago, Ill., February 22, 1922

stillborn show that the shape of the chest and the abdomen is ovoid, the bulging no doubt being the result of the large liver. The lower ribs flare to accommodate themselves to the wide upper abdomen. The upper pole of the thoracic cage is distinctly narrowed. The ribs are sloping. There is an even density throughout both the lung fields, and the heart shadow cannot be differentiated from the lung tissue. Immediately after respiration, there is a distinct

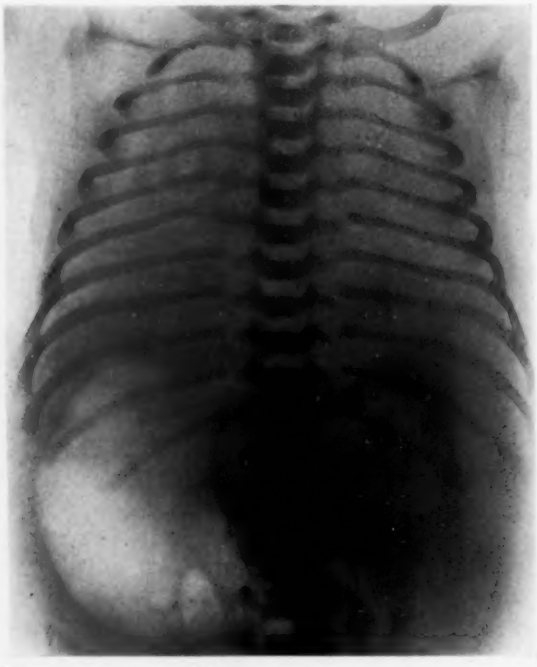

FIG. 1. Chest of stillborn. Forced expansion used. Note gas-distended stomach and cone-shaped chest.

change in the contour of the chest. The ribs elevate and lie at right angles to the spine, and the upper thoracic cage shows a definite increase in the diameter. On several of the plates which we obtained, the tracheal shadow was shown throughout. This negatives Mink's contention that the fetal air passages are collapsed and that the glottis and nostrils are closed.

This series of plates of the newborn includes a number of cases where insufflation of the lungs was done with the gas machine. In all these cases we found gaseous distension of the stomach and intestines, but as far as we could determine, no changes were produced in the lungs themselves. In the first case we studied, the disturbed respiration was associated with enlarged thymus and incomplete expansion of one of the lungs; that is, one of the lungs remained in part atelectatic. In the remaining cases where the impairment of respiration was of sufficient importance to warrant treatment with the gas machine, we found a complete expansion of the lungs, but a wide upper mediastinal shadow, which we interpreted as thymus. Plates of these cases showed, as referred

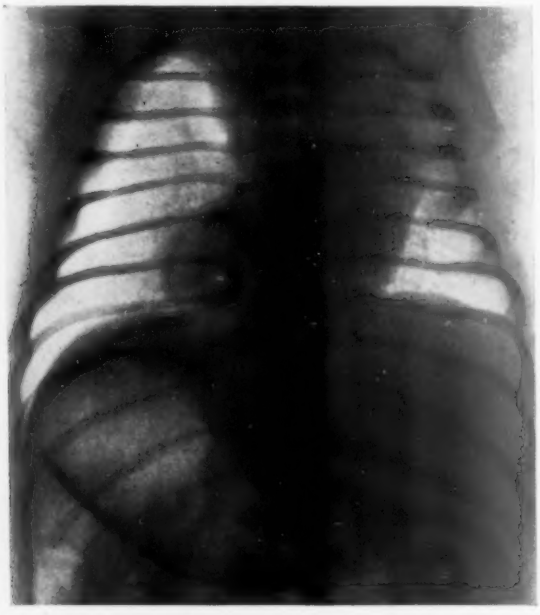

FIG. 2. Case of asphyxia neonatorum. Forced expansion used. Note gas-distended stomach and wide thymus shadow. Also note expansion of upper thoracic cage.

to previously, gaseous distension of the stomach.

Experiments with the insufflation of the lungs of the stillborn by means of a catheter passed into the trachea, demonstrate that it is impossible to inflate the lungs by air pressure. Rather, there is an early rupture with the escape of the air into the pleural cavities which is sufficient to distend the chest wall. Usually pressure equal to 10 mm. of mercury is considered the limit of safety in forcible expansion of the lungs in infancy.

Our conclusions as to the efficacy of insufflation for faulty respiration are that the procedure has no merit, and that it has the disadvantage of widely distending the stomach and intestines.

THE THYMUS GLAND AS A FACTOR IN ASPHYXIA NEONATORUM

As to the large thymus gland being the basis for the faulty respiration, we have conclusive evidence that in practically every case the symptoms result from pressure on the trachea. The severity of the symptoms is not always in direct proportion to the enlargement of the thymus shadow, but the fact still remains that there is a constancy between the large thymus shadow and the faulty respiration. The thymus gland was exposed by removal of the sternum in several cases. The gland appeared in the median line, projecting no more to the right than to the left. The average length of the gland was about three

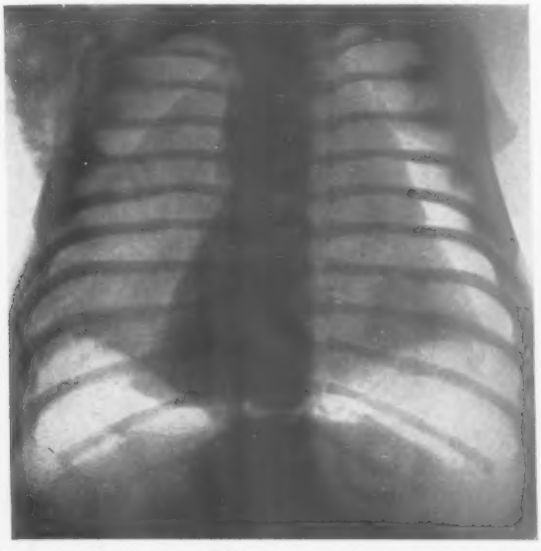

FIG. 3. Chest of stillborn. Forced expansion by gas machine and expansion through tracheal catheter used. Lungs not expanded. Note pneumothorax and gas-distended stomach.

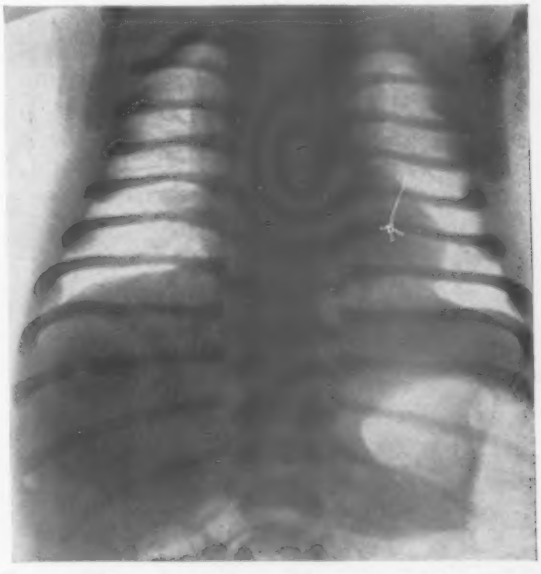

FIG. 5 Plate of newborn with asphyxia. Note broad upper mediastinal shadow due to large thymus gland.

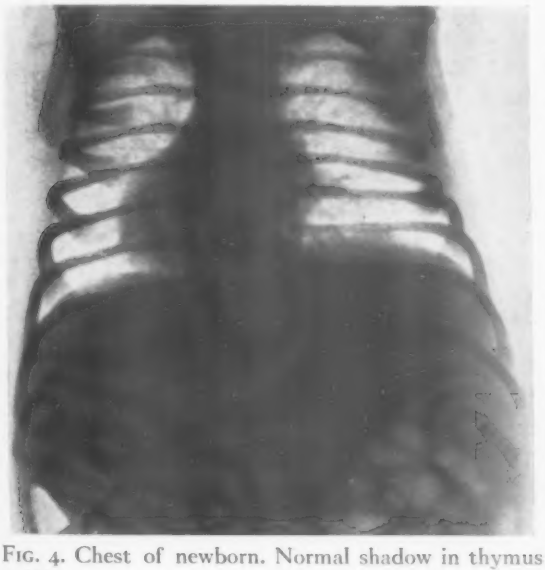

FIG. 4. Chest of newborn. Normal shadow in thymus area.

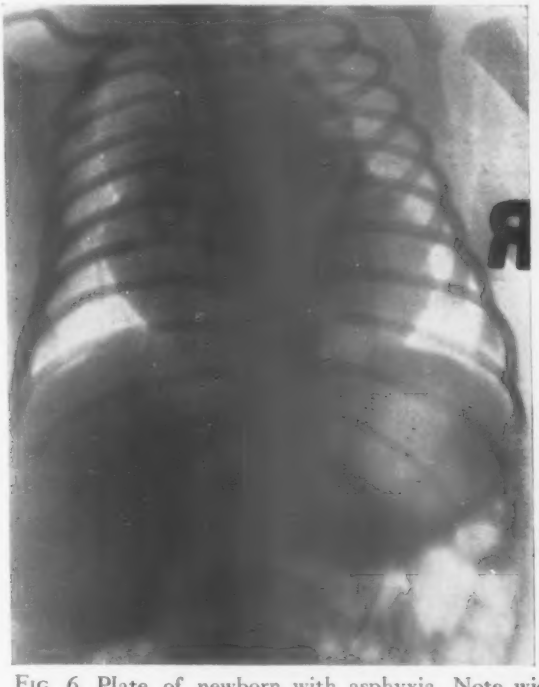

FIG. 6. Plate of newborn with asphyxia. Note wide thymus shadow.

inches, and the width a little more than an inch. We concluded from the post-mortem studies that the shadow of the normal thymus gland could not be differentiated from the shadow of the spine.

While we found a wide upper mediastinal shadow in most of the cases presenting respiratory symptoms, it is also true that in a number of cases of these wide shadows there was no disturbance in respiration.

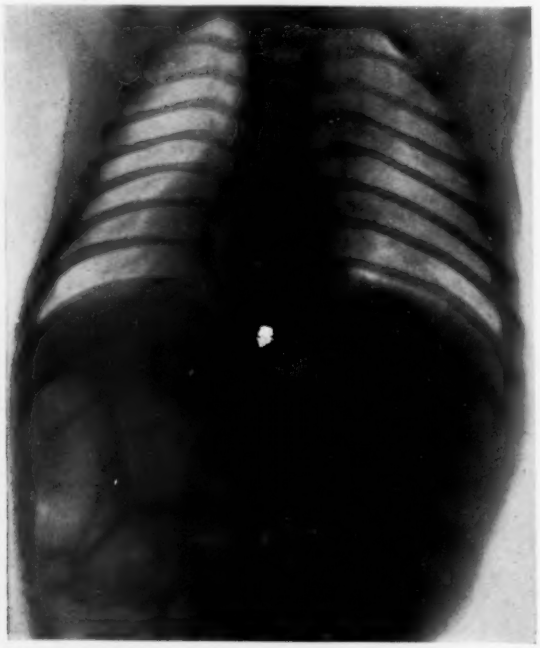

FIG. 7. Plate of newborn with asphyxia. Upper right lung atelectatic. Note extension of thymus shadow to right.

In three of the cases studied, there was incomplete expansion of one lung. As the lungs expanded, the expansion being checked by serial plates, there was improvement in the respiration. In searching for a possible cause of the non-expansion of the lungs, it was noted that in all cases of unilateral atelectasis, the lobe of the thymus on the affected side showed the greater enlargement. It seems a fair conclusion that the enlarged thymus may even be a factor in the failure of the lung to be properly aerated.

In several of the cases there was a definite deformity of the cardiac outline. No doubt, disturbed circulation is an important factor in asphyxia neonatorum, but sufficient work has not been done on the heart to permit of proper classification of cardiac deformities or the determination of the frequency of cardiac complications.

DISCUSSION

DR. BISSELL. My discussion will take the form of an inquiry. I would like to ask relative to the treatment of these cases first, whether Dr. Evans noted marked aggravation of the symptoms following treatment before there is

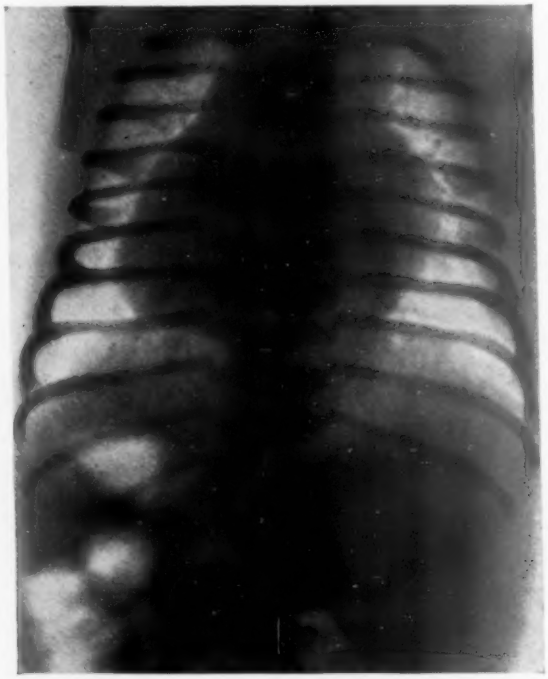

FIG. 8. Plate of newborn with asphyxia. Note cardiac deformity and atelectasis of upper left lobe.

improvement. In the cases which I have seen in which there was marked stridor so that there was no doubt about the respiratory involvement, the patients have shown marked aggravation of symptoms following treatment, so that in two or three instances the physicians in charge have been very much alarmed and would not let the patient go out. The next day there was marked improvement.

Another question is whether he has had opportunity to ray these cases following treatment and see whether there was a concomitant reduction in the size of the gland as well as improvement in the symptoms. My personal observation has been that the improvement is due to some functional change rather than an actual reduction in gland tissue.

DR. MURPHY. I would like to ask Dr. Evans whether he has had any cases in which

there was a reduction in the symptoms, but the baby did not recover and showed signs of generalized tuberculosis throughout the chest. I had one case in which the baby recovered from the thymic asthma, but died some months later from what appeared to be a generalized miliary tuberculosis of both lungs.

Dr. Allison. I would like to make an inquiry; that is, regarding these cases that are coming in showing unquestioned thymic disturbances and yet no enlargement of the thymus in the *x*-ray plate, but a beautiful response to *x*-ray therapy. I wonder if we do not have an anteroposterior enlargement of the thymus. We see a lateral enlargement quite commonly on the plate, but I have wondered whether we could not demonstrate a lesion in the light shadow which Dr. Evans described as the anterior mediastinum. I wonder if the thymus is not enlarged from before backward rather than from side to side.

Dr. D. Y. Keith. I think it would be well for Dr. Evans to tell us if an autopsy was held on these patients and whether there was an atresia of some portion of the bronchus below, particularly in the child that was stillborn.

Dr. Potter. I do not see these children very early, but frequently they come to the office and the referring physician will give some sort of instructions like this,—that we should do whatever we can to find out whether the child has a thymus and do whatever we can to cure him of it. These children are several days old at least when I see them. It is our custom to fluoroscope the babies and see what we think about the shadows and then make a study of the plates to see if they will show anything. Then we run them right into the treatment room if they are breathing hard or if an obstruction is shown under the fluoroscope. I believe the therapeutic test in symptomatic thymus cases is worth more than the roentgenogram for showing the presence of a thymus that will give real symptoms. You can have a thymus or thyroid so situated in the median line that it will give dyspnea or obstruction, but it will defy recognition by the *x*-ray. I know a doctor whose daughter showed some very moderate signs of obstruction with a little thyroid in the neck. She had perfectly negative upper mediastinal shadows. He went to Boston to visit her and found that she was going around with signs of pressure; in fact, any one could recognize them as signs of pressure. He took her to an internist who agreed with him and again they rayed her. Still there were negative findings. She was operated upon, and a long lobe of thyroid was found sticking down in the chest which was plenty large enough to give any amount of obstruction. She was immediately relieved clinically. So I think we must, as some of the speakers said, discount our negative findings in thymus cases where there is probably an obstruction due to the thymus, and go ahead and treat them. Inasmuch as the ray is such a good way to treat them, a therapeutic dose is usually given.

Dr. Hickey. Along the line of Dr. Potter's case I would like to refer to a case, a child that passed under our observation. I do not remember the age exactly. The clinical diagnosis was probably thymic obstruction. She was sent in to be rayed. We could not find any enlargement of the thymus and we reported it so, though we thought it might be a good plan to treat the child. She received several therapeutic doses and was not any better. The case then fell into the hands of a nose and throat man who thought it would be a good plan to look down the child's larynx. He did so and found a tumor, which he removed.

Dr. Evans (closing discussion). I want to point out that this work was all done during the first few hours of life. We were dealing, not with the clinical type of enlarged thymus as we get it in children after two weeks or a month, but with the disturbed respiration of the newborn. I think that will answer Dr. Murphy's question regarding the diseases of respiration. We did not secure a reaction in any of the cases, and we treated quite a large number. We got no increase in the symptoms in the cases treated. As Dr. Murphy suggests, we encounter this sometimes in treating older children.

Regarding atresia of the air passages, Dr. Keith, we did a post on the case and there was no atresia. Just why the child was stillborn we did not determine. We made lateral studies of these chests, and we were not able to show anteroposterior compression of the trachea due to enlarged thymus. It is difficult to demonstrate enlarged thymi in the stillborn.

A SIMPLIFIED PNEUMOPERITONEUM TECHNIQUE

BY L. R. SANTE, M.D.

Assistant Professor of Roentgenology, Medical Department, St. Louis University; Roentgenologist to St. Louis City Hospitals

ST. LOUIS, MISSOURI

IN 1919, pneumoperitoneum, as an aid in roentgen-ray diagnosis, was first introduced into this country by Stewart and Stein.[1] Since that time the method has been taken up by many roentgenologists all over the country and thousands of examinations have been made. Recently, after an exhaustive study from many American sources, Case[2] has reported the inconveniences and dangers which he feels are attendant upon the process. He has collected reports of 4 cases in which death was directly attributed to the performance of pneumoperitoneum. This investigation is timely, and serves very well to point out the dangers of the procedure. It will no doubt stimulate other roentgenologists to attempt the formulation of a safer technique. Assuming that in addition to these four deaths several others have occurred which have not been reported and consequently have not come to light, is this sufficient ground upon which to reject such a valuable procedure? By no means. It merely shows us that the method is not without danger when using present technique and apparatus, and it should stimulate us to perfection of a safer technique.

It behooves us then, as roentgenologists, to establish some simple, convenient technique which will bring pneumoperitoneum to the point of practical safety.

An investigation of the apparatus and procedure in general use for the production of pneumoperitoneum shows that they vary widely. It is unfortunate indeed that many have deviated from the recommendation made in the original paper of Stewart and Stein to maintain simplicity in apparatus and procedure. Where oxygen is used, a tank of this gas is connected by suitable tubing to a lumbar puncture needle. Many have added to this apparatus manometers and sterile water bottles for "washing" the gas before introduction into the peritoneal cavity. Some have even introduced devices to measure the quantity of gas introduced. Others have utilized a large rubber bag which is inflated before the needle is introduced into the peritoneal cavity. With this arrangement the needle is attached by rubber tubing directly to the bag and is inserted into the abdomen with the stream of gas flowing from the bag through the needle. The resistance of the subcutaneous tissues against the end of the needle permits very little escape of the gas; when the abdominal cavity is entered, however, the sudden release of pressure is indicated by the rapid deflation of the bag. With this arrangement it is much easier to cause puncture of a blood-vessel, since the needle is introduced without the stylet in place. If such an accident should occur, it could not be detected and air embolism would surely result. Where carbon dioxide alone is used, a similar apparatus has been advocated, allowing a definite amount of carbon dioxide to accumulate in a rubber bag, connecting the needle before the puncture is made, and inserting it without the trocar in place. Where a combination of carbon dioxide and oxygen is used, even more extensive apparatus is required. The procedure advocated has been equally complicated and varied in each instance.

To establish pneumoperitoneum as a successful procedure it must fulfil certain requirements.

1. It must be capable of production with simple apparatus which can be easily secured.
2. It must be readily performed by the roentgenologist himself or an assistant.
3. It must be convenient for the operator and not consume too much time.
4. It must be safe as regards the life and condition of the patient.
5. It must be of least possible discomfort to the patient.

The apparatus and procedure which we have used successfully during the past two years will be briefly outlined, in the belief that they come nearer to fulfilling these requirements than any other procedure yet advocated.

On the evening before treatment the patient is given a cathartic, preferably castor oil, and the next morning, about thirty minutes before examination, a soap suds enema. This is essential for the success of the examination. Omitting to rid the intestinal tract of gas and fecal material will result in failure. A light breakfast may be allowed, but this should not exceed two slices of toast and a cup of coffee. In approximately 175 cases in which pneumoperitoneum has been performed, there has been vomiting only once; this was in a patient who, disregarding these instructions, partook of a heavy meal just before examination. This merely added a disagreeable phase to the examination. Fifteen minutes before inflation, the patient should receive 1/6 gr. of morphine sulphate to relieve any apprehensiveness and discomfort which may result from inflation. Just before inflation he should be catheterized or caused to void, so that an empty bladder during inflation will be assured.

With these preliminaries, preparation is made for inflation. The patient is placed on a hospital stretcher in a convenient position so that the stretcher can be rolled before the vertical fluoroscope. Special types of tables have been constructed for this purpose[3] but these are not essential; they merely add to the convenience of making the examination. With the patient lying on his back, and the entire abdomen exposed, the left lower quadrant is prepared for injection. The entire abdomen is washed with green soap and water, is rinsed, and then dried. Tincture of iodine is liberally applied to the left lower quadrant, and allowed to dry. This may be either removed with alcohol or allowed to remain, according to the desire of the operator. It would seem better to allow it to remain, since the demarcation of the iodine is an ever-present indication of the antisepticized area. The remainder of the abdomen is draped with sterile towels. The operator should prepare as for any other surgical procedure: scrub his hands with liquid soap and warm water, using a brush, for fifteen minutes, and should use sterile rubber gloves.

The patient is then ready for inflation. The inflating apparatus used is very simple (Fig. 1). It consists of a pump, such as that used with a Potain aspirator, which is connected by rubber tubing and suitable connectors to an ordinary lumbar puncture needle, with a rectal drip (vent-hole plugged) interposed as a trap to prevent any possible introduction of

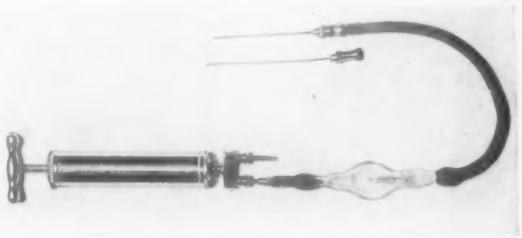

FIG. 1. Apparatus used for production of pneumoperitoneum. An ordinary lumbar puncture needle fitted to the pump of a Potain aspirator by suitable rubber tubing and connectors with a rectal drip interposed as a trap (vent-hole plugged).

foreign material from the pump. With the exception of the pump, the entire apparatus is sterilized by boiling for fifteen minutes.

The abdomen should be palpated over the site of the operation, so as to detect any possible abdominal masses or abnormal pulsations. The site most suitable for puncture is 1½ to 2 inches to the left of, and a similar distance below, the umbilicus. The left lower quadrant is chosen rather than any other, because in this position there are no solid abdominal organs, the sigmoid and descending colon are situated far posteriorly and there is rarely any inflammatory process encountered such as is attendant upon appendical involvement. Anomalous conditions of the bladder will be avoided by inserting the needle on one side of the midline and by emptying the bladder before introduction of the needle.

The only structures which must be contended with are the deep epigastric artery in the abdominal wall, the intestines and the mesenteric vessels within the

abdomen. If all manipulation of the needle within the abdomen or in the abdominal wall is carried out only when the stylet is in place in the needle, there will be little danger from puncturing a vessel. We have repeatedly attempted to insert a lumbar puncture needle in the veins of the forearm when the stylet was in place, and have been unable to do so except with great difficulty. If the obturator is withdrawn, however, the puncture of a vessel becomes a much simpler matter. Puncture of the intestines should be a very remote possibility if the stylet is in position and no adhesions are present. Postoperative scars should be avoided.

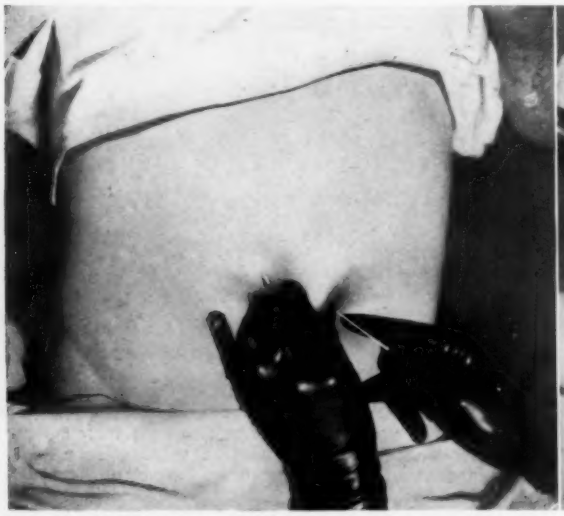

FIG. 2. The skin and subcutaneous tissues of the abdomen are grasped firmly between the thumb and the index finger of the left hand and raised away from the abdominal structures. The needle, stylet in place, is held firmly in the palm, the point being guarded about one inch from the end by the extended index finger. The point of the needle, guided by the posterior aspect of the left thumb, is inserted into the subcutaneous tissue.

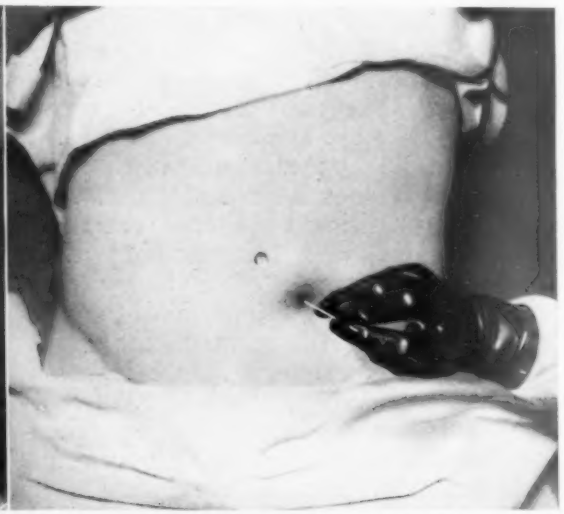

FIG. 3. With the index finger over the hilt, and the barrel of the needle grasped between the tips of the fingers and thumb, firm but steady pressure is exerted. Two distinct impulses will be felt, one as the needle traverses the fascia, the other as the peritoneum is pierced.

Having observed these preliminary precautions, we may proceed with the insertion of the needle. The needle should be disconnected from the apparatus and the stylet inserted. No local anesthetic is necessary for the passage of the needle. The skin and subcutaneous tissues of the abdomen are grasped firmly between the thumb and index finger of the left hand and raised away from the abdominal structures (Fig. 2). The needle, stylet in place, is held firmly in the right hand, the heel of the needle resting against the palm, the point being guarded about 1 inch from the end by the extended index finger. The point of the needle, guided by the posterior aspect of the left thumb is inserted into the subcutaneous tissues of the abdomen. In traversing the remainder of the abdominal wall, the needle is held almost perpendicular, directed slightly upward and inward so as not to put the mesentery on a stretch, should the needle-point come in contact with the intestines. With the index finger over the hilt, and the barrel of the needle grasped between the tips of the fingers and thumb, firm but steady pressure is exerted (Fig. 3). Two distinct impulses will be felt, one as the needle traverses the fascia, the other as the peritoneum is pierced. To be sure that the needle projects into the abdominal cavity the following test is then applied (Fig. 4). Holding the needle carefully, the stylet is withdrawn, and the apparatus connected. A few strokes of the pump will be sufficient for the purpose. If the needle is in the abdominal cavity, the inrushing air can be heard with each stroke of the pump, by a stethoscope placed at some remote position on the abdomen. This same method can be

utilized in detecting the entrance of air into the abdominal cavity through the tubes, in transuterine insufflation. If this characteristic sound is not heard, the needle has not yet traversed the abdominal wall; the apparatus should be disconnected, the stylet reinserted in the needle and the needle inserted farther. The needle should never be manipulated unless the stylet is

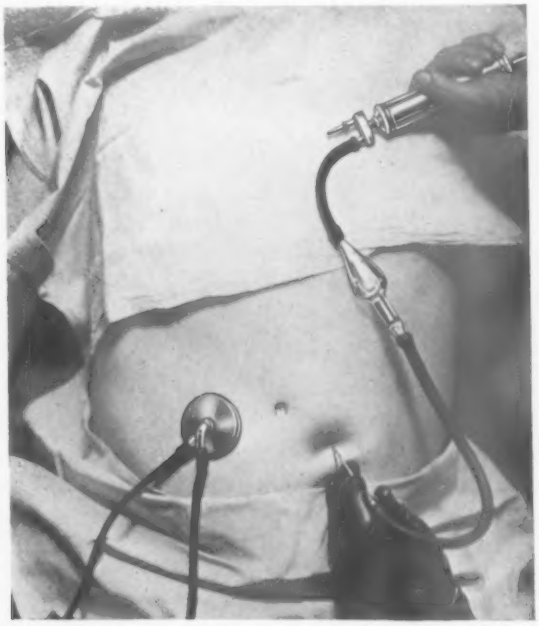

FIG. 4. To be sure that the needle projects into the abdominal cavity the following test is applied. Holding the needle carefully, the stylet is withdrawn and the apparatus connected. A few strokes of the pump will be sufficient for the purpose. If the needle is within the abdominal cavity, the inrushing air can be heard with each stroke of the pump by a stethoscope placed at some remote position on the abdomen. If this characteristic sound is heard you can be sure that the needle is in the peritoneal cavity. If it is not heard, you can be sure that the needle has not entirely traversed the abdominal wall.

in place. The slight amount of subcutaneous emphysema resulting from the injection of a few syringefuls of air into the subcutaneous tissues is of no consequence. The short space of time which elapses between the withdrawal of the stylet and the connection of the inflating apparatus is sufficient to detect the presence of the needle in a blood-vessel, should such a mishap have occurred. Air embolism should thus be entirely avoidable.

When the presence of the needle in the abdomen is assured, by the characteristic sound heard with the stethescope, the stretcher is rolled to a position before a vertical fluoroscope (Fig. 5), and inflation is continued under the guidance of fluoroscopic examination.

We use as a criterion of proper distention, the slight rounding of the abdomen and development of a tympanitic note over the entire abdomen. Inflation before the fluoroscope, however, as recommended by Orndoff,[4] is the most satisfactory method of determining proper distention. If an intra-abdominal mass is present, distention must be carried to a point far enough to lift the anterior abdominal wall free from the mass. This is necessary to determine the possible attachment of the mass to the anterior abdominal wall. Where the retroperitoneal space is to be examined, a slightly greater degree of inflation is necessary. Sterilization of the air is not necessary, since air infection does not occur in abdominal operations. The pump, of course, should never be used for aspiration of infected cases. Measuring devices are of no value, since lax pendulous abdomens may accommodate several liters of air and rigid tense abdomens, less than a liter. For the same reason, intra-abdominal pressure is likewise no guide to the suitable amount of air to be used. When proper distention has been obtained, the needle

FIG. 5. The stretcher is rolled to a position before the vertical fluoroscope and inflation is continued under the guidance of fluoroscopic examination.

should be withdrawn and the examination proceeded with, before the fluoroscope. The patient is examined before the vertical fluoroscope, first on the back, then on either side, and finally in the retroperitoneal position. This position[5] may be secured by placing the patient in the prone position supported by two blocks; one beneath the chest, the other beneath the thighs. Examination before the vertical fluoroscope reveals the retroperitoneal structures. The patient is then transferred to the horizontal fluoroscope and examined while on the back and on the abdomen. Roentgenograms can then be made in any of the positions desired.

After the examination is completed, a second sterile lumbar puncture needle is inserted through the same hole into the abdomen, the obturator removed, and the air allowed to escape. Gentle pressure on the sides of the abdomen may be necessary to express the air. All the air cannot be thus removed, but the residual quantity is so small that its presence is of no consequence. Within a few days it is entirely absorbed. Do not use the suction arrangement on the pump to withdraw the air unless the second lumbar puncture needle used (an instrument recommended by Tierney[6]), has been filed off flat. With proper cooperation, the entire procedure, from the time of inserting the needle to the withdrawal of the air, should not consume more than twenty to twenty-five minutes. Consequently, before the effect of the morphine administration has worn off, the procedure is over.

A brief consideration will show that this procedure complies very closely with the requisites of an ideal method.

The apparatus is simple, inexpensive and can easily be secured by everyone.

Pneumoperitoneum can readily be produced with this apparatus, by the roentgenologist himself. In practically all cases where fatalities have been reported due to its production by other methods, the mishap was in the hands of the casual user. To be of proper usefulness it should be so simple that it could be safely performed even by the casual user. That the method here advocated can be safely performed by any physician who has a fair conception of anatomy and the principles of asepsis, after practicing five or six times on dogs or cadavers, there is no doubt. Any physician who has not a fair conception of anatomy and aseptic principles has no excuse for practicing medicine. As an evidence of the wide applicability of this method, it can be stated that of approximately 175 successful cases which we have had, not more than 2 have been performed by any one man (with exception of those performed by the author himself) and that these men were all internes just out of college.

The convenience of this procedure is evident. No special apparatus is necessary; no tank of gas is required. That it is absolutely safe as regards the life and the condition of the patient, cannot be positively asserted. But that it is far safer than some other diagnostic methods employed daily by internists and surgeons, there is no doubt in the mind of the writer.

With the use of air as an injecting medium we find far less discomfort than with oxygen or other gas, a fact which has been noted by internists in artificial pneumothorax. When used in conjunction with morphine injection, the discomfort is so much reduced that the patient usually goes through the entire examination without complaint.

The aim of this paper will be fully realized, if the reading thereof shall stimulate, to any degree, the further investigation of this valuable method.

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OSGOOD-SCHLATTER'S DISEASE*

BY ELLIS R. BADER, M.D.

Visiting Roentgenologist, Cincinnati General Hospital

CINCINNATI, OHIO

IN reviewing the literature pertaining to Osgood-Schlatter's disease, one notes with interest that the first case report of this condition was in 1869 by Dr. Paul Vogt. One cannot help but admire the diagnostic ability displayed in the early days, long before the use of the *x*-rays; and considering the comparative rarity of this condition, which is practically never diagnosed to-day except in conjunction with positive *x*-ray findings, one again marvels at the skill of the old practitioner.

Another interesting point, worthy of note in passing, is the absence of articles dealing with this condition in the roentgen-ray journals. The rather exhaustive reports by Osgood in the *Boston Medical and Surgical Journal*, and by Schlatter in German—both of which appeared in 1903—have no counterpart in the roentgen-ray journals.

A condition which depends to such a great extent upon the roentgen-ray findings, therefore, seems worthy of mention, from a roentgen-ray standpoint. In considering the incidence of this disease, the records of the Cincinnati General Hospital were found to show one case of Osgood-Schlatter's disease in six years. This apparent rarity may be somewhat discounted by the fact that this condition is not necessarily hospitalized.

Osgood-Schlatter's disease, as it is commonly called, may be classified either as a disease or as an injury, although it would seem that the classification as an injury is particularly applicable, as the condition is primarily due to trauma.

The severity of the lesion ranges from a non-suppurative, subacute inflammatory thickening of the tibial tubercle, due to repeated traumata of ligamentous pulling, to a complete avulsion of the tibial tubercle by sudden muscular contraction. This condition is primarily seen in adolescence, and usually in young people of the athletic type who have occasion to use the quadriceps femoris rather vigorously. In adults, the complete avulsion of the tibial tubercle is most commonly found, and the non-suppurative inflammatory type rarely.

A brief review of the development and anatomy of the upper end of the tibia may not be amiss, since the pathology depends to a great extent upon the developmental anatomy. The upper portion of the tibia usually develops from one center of ossification, which forms the upper articular surface and a tongue-like projection, or beak, anteriorly, and extends downward over the diaphysis. There may be, however, a separate center of ossification for the tibial beak. Ossification is usually not complete until from puberty to twenty years.

Attached to this tibial tubercle is the tendon of the quadriceps femoris. This tendon also sends out lateral aponeurotic

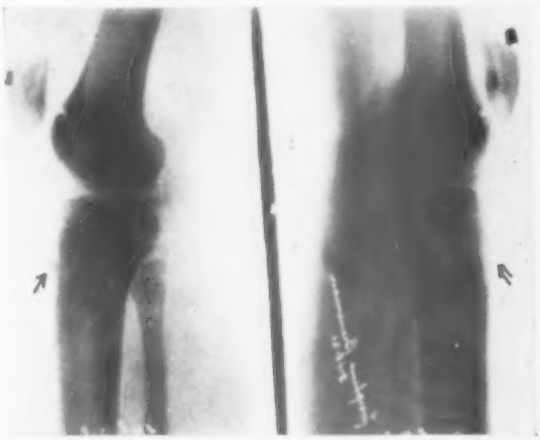

FIG. 1.

expansions which are attached to the anterior portion of the tibia and to the internal and external sides of the tibial beak. This latter fact accounts for occasional fractures of the tibial beak which apparently cause no loss of extensor power of the quadriceps femoris. In other words, although the direct attachment of the

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quadriceps ligament is separated, its lateral expansion remains intact.

Figure 1 shows the knees of a very athletic girl about ten years of age who was taken to the family physician by her mother on account of small painful lumps below the knees—the right knee, especially being most marked. There was no loss of muscular power. The lumps were tender to touch, and also painful upon forcible

FIG. 2.

exertion. There was a slight redness, but no appreciable increase in local temperature.

The roentgenogram showed an irregular and fuzzy tibial beak, rather moth-eaten in appearance, suggesting low-grade inflammatory changes. The left tibial beak showed no evidence of pathology, from the roentgen standpoint.

This case is an example of the typical Osgood-Schlatter disease, of the non-suppurative, subacute inflammatory type. The treatment in this case was firm strapping of the knees and tibial tubercle with adhesive bands.

Figure 2 shows the left knee of an athletic boy of nine years, who sustained an injury to this knee. He was pushed off a fence by another boy, and landed on his feet, with the knee in a slightly flexed position. He immediately fell to the ground, and was thenceforth unable to extend the left leg. The roentgenogram showed a separation of the tibial tubercle, about 1 inch upwards from the normal position. This is another case of Osgood-Schlatter's disease, but with complete avulsion of the tibial beak. This patient was treated by open operation. The tibial tubercle was attached to the tibia by kangaroo-tendon.

In exposing these plates, one should remember to have the knees so centered in relation to the tube that the central ray passes through the tibial tubercle, directly perpendicular to the plate. It is also a very good idea to expose both knees, should only one knee be affected, thus allowing a check of the normal with the pathological.

Clinically, Osgood-Schlatter's disease must be differentiated from tuberculosis of the knee, bursitis, infectious arthritis, fracture of the patella, periostitis, joint fringe, and loose cartilage. The roentgenogram, of course, is the deciding factor in making the differential diagnosis.

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DISCUSSION

DR. BLAINE. I have seen a few cases of Osgood-Schlatter's disease, but I fail to see how we can call this a diseased condition when, as in the second instance which Dr. Bader presented, it is really a trauma. Why do we call it Schlatter's disease? It seems to me it resolves

itself into a disease of the tibial epiphysis. On one hand the changes follow long after the injury, and the inflammatory process is so marked that it rightly would be a disease of the tibial epiphysis; but on the other hand, where the change happens in a normal boy or girl with a tearing or fracture, as in the elbow or in the other joints, it is the result of trauma, and is not a disease.

Mr. Dachtler. I had a case recently, a boy of thirteen, who presented a swelling, very slightly sensitive, over the tubercle of the tibia. I expected to find Osgood-Schlatter's disease, but on examination he was found to have a bilateral new-bone formation which was not attached to the tibial spine. It was like a calcification in the bursa, and there was no temperature. I sent him to our orthopedic surgeon, who told me he had two or three similar cases, one of them bilateral. I think Dr. Murphy saw these cases. It was not Osgood-Schlatter's disease, but clinically it would give one that impression. There was no irregularity of the tibial spine, and the only thing we could liken it to was a calcification in the bursa.

Dr. Murphy. I think I can recall the case Mr. Dachtler mentioned. If my memory is dependable, it showed an osteomyelitis when operated upon. I believe there was no injury in that case, but it was purely an infection of the tibia. That is quite a different condition from one brought about by sudden trauma. We all see cases in which there is a definite enlargement of the tibial tubercle. I think that is a condition similar to Perthes' disease of the hip, simply an inflammatory condition of the epiphysis of that joint. There should be a distinction between that and the traumatic type in which there is a fracture.

Dr. Keith. I would like to ask Dr. Bader if there was any bacteriological examination in the cases reported. I believe that in the cases that go to suppuration we should make a culture or animal inoculation, in order to tell definitely what we are dealing with from a bacteriological point of view.

Dr. LeWald. I have seen a number of these cases. I think the thing of importance to emphasize is that they are non-tuberculous; at least all our cases have finally cleared up without suppurating or breaking down, without the formation of sinuses and without requiring operative intervention. It is very difficult from the roentgen-ray appearance alone to make a diagnosis, for one will see irregular variations on the two sides, sometimes both of them very prominent, with an irregular epiphyseal line. In some cases, this process is entirely separated from the tibial shaft. I think one should be very cautious in making a diagnosis without the clinical history. If you have a focus there, you can say it is a diseased condition; if there is an irregularity of the epiphysis, it may be an irregularity in formation. It is a good deal like a discussion on the cecum which I once heard. The surgeon said if the cecum was loose you sewed it up, and if it was surrounded by adhesions you loosened it up.

Dr. Bader (closing discussion). I agree with Dr. Blaine in thinking the disease should be classified both as a disease and as an injury. The last 2 cases I showed were fracture cases and these, I think, should be classed as fractures rather than diseases.

In answer to Dr. Keith's question: I looked over the literature on this subject rather thoroughly and did not come across any cases in which bacteriological examinations had been made.

OSTEITIS DEFORMANS (PAGET'S DISEASE)

BY CECIL M. JACK, PH.B., M.D., F.A.C.P.

DECATUR, ILLINOIS

THE following case of osteitis deformans is reported to illustrate the value of the roentgen-ray examination to the internist in the diagnosis of his obscure cases. Without it, perhaps, this case would have remained obscure.

CASE 20,694. Male, minister, Aged forty-six, married.

CLINICAL HISTORY

Past Medical. Patient was never sick until ten years ago. Since that time he has been ill quite frequently. He had inflammatory rheumatism nine years ago; hemorrhoidectomy seven years ago. Five years ago he had a severe, sharp, acute pain in the right upper lumbar region, lasting twelve hours and relieved only by morphine, diagnosed as a kidney stone. He had a similar attack in January, 1920, which came on very suddenly. In September, 1919, he had an acute cystitis. He was in bed five weeks, and recovery followed soon after a sudden discharge of a large amount of blood and pus.

Family History. No tuberculosis nor cancer. Father is past seventy and well. Four children living and well.

Habits. Appetite remains good, bowel movements regular, no urinary disturbances, except a mild nocturia.

Present Complaint. Impaired vision, headaches, soft area in cranium, fever and weakness.

Onset and Course. Trouble began in August, 1920, following a week or two of diminished energy and vitality. He first noticed sudden severe pains in the head, and consulted a physician for relief two days later; his temperature was 101.5°F. On the following day the temperature went to 103°F. and the patient was obliged to go to bed, where he remained two days. On the following day the pain disappeared and the temperature went down. Two days later the temperature rose again to 102°F. and his headache became severe. Since then he has had headache almost every day. He states it would quite regularly become severe about every second day. He has also had fever occasionally.

On October 5th, he first noticed blurred vision, which progressed rapidly, and in a few days he was unable to read. He consulted an ophthalmologist who said it was eyestrain. The patient obtained some glasses which aided him in close vision; his distant vision, however, remained blurred. At present the patient sees with great difficulty and at times has diplopia.

A soreness has been present at the apex of the cranial vault during the illness, but about two weeks ago he first noticed a puffy, soft area which seemed to contain fluid. It is surrounded by a sensation of pressure and tightness. The patient states that he is somewhat weak and cannot exert himself. The teeth have been roentgenographed, and several, which were abscessed, extracted.

PHYSICAL EXAMINATION

The patient appears well-developed and well-nourished. He suffers no pain; his hearing is normal; his speech approaches the scanning type. Temperature, pulse and respirations are normal. His height is 5 feet, 10½ inches, one inch less than in his student days, and he weighs 176 pounds, which he considers normal.

The head presents a soft and fluctuating area, about the size of a silver dollar, in the vertex region, apparently an area of necrosis involving the skull. The border of this area is bony and the base is soft. The left pupil is larger than the right; both react well to light and accommodation. A slight divergent strabismus is present. The retinae are congested, and the outline of the discs cannot be made out. Several flame-like areas are seen, particularly on the right side.

The abdominal reflexes are absent. The patellar reflexes are equal but exaggerated. The other reflexes are normal.

The remainder of the physical examination is negative.

LABORATORY FINDINGS

Blood-Pressure. Systolic 135; diastolic 80.

Urine. Negative.

Blood. Hemoglobin 70 per cent, red cells 2,920,000, white cells 9,200; color index 1.

Differential Cunt. Polymorphonuclears 60, large mononuclears 1, small mononuclears 38, and transitionals 1.

FIG. 1. Head roentgenogram showing variations in density and thickness of cranium. Note the irregular areas of bone scattered over the vertex.

Wassermann Reaction. Negative. Four tests made during treatment.

Spinal Fluid. Pressure increased; clear; cell count normal. Nonne negative; Wassermann negative, and colloidal gold test 000 000 000 0.

Basal Metabolism. Metabolic rate plus 10 per cent.

ROENTGENOLOGICAL EXAMINATION

Skull. There is a spongy appearance of the compact layer, with increased transparency. The skull is greatly thickened, which is in contrast to its transparency. All through the skull roentgenogram there are scattered irregular spots which could be compared to tufts of cotton.

Chest. The apices are clear; peribronchial infiltration is quite marked; and the costophrenic angles are clear. The heart is definitely enlarged, and the aorta is broadened.

Long Bones. In the tibia and femur, there is an absence of definition of cortex and cancellous tissue with no areas of rarefaction. The bones are more dense than normal throughout. The sclerosed arteries cast a distinct shadow.

Pelvis. A condition similar to that seen in the skull is found in the pelvic bones, more marked on the left than on the right side.

Diagnosis. Osteitis deformans or Paget's disease.

Course. The patient was given a course of six intravenous injections of neoarsphenamine, and the turn for the better was remarkable. The vision cleared, the headaches stopped, the soft spot in the head disappeared, and he gained in weight and felt better in every way. After six weekly gluteal injections of mercury he was given six more intravenous injections of neoarsphenamine.

CONCLUSIONS

We are dealing here with a chronic generalized bone disease characterized clinically by an enlargement of the cranium and deformities of various other bones, and pathologically by a rarefying and productive osteitis.

General arteriosclerosis is a practically constant lesion in cases of Paget's disease. Hypertrophy of the heart is also a constant feature. Both are marked in this case. According to Lannelongue,[1] Paget's disease is a manifestation of hereditary syphilis in the aged, and he bases his opinion on the similarity of the lesions. This is interesting, as improvement in this case followed the giving of neoarsphenamine. A case reported by Dufour and Bertin-Mourot[2] improved in like manner. However, their case gave a positive Wassermann reaction. A diagnosis in the early stages is difficult, and, as a rule, it is not until the case becomes fully developed that it is recognized. For this reason many people suffering from Paget's disease are treated for a long time for rheumatism, neuralgia, etc. Again, it has been found that some

cases which early simulate a Paget's disease turn out to be some other condition.

With Paget's description[3] of an early case this patient has very little in common. On subsequent questioning we find that the hats he formerly wore are now all too tight and that he has lost an inch in height in twenty years. A roentgenogram, though taken only on account of his eye findings and headaches, disclosed also that we were dealing with a disease which needed further investigation, whereupon other roentgenograms were taken. Then the diagnosis was apparent.

This case gives no serological nor clinical test for syphilis. However, improvement has been marked under antiluetic treatment and suggests the possibility of Paget's disease being a manifestation of late hereditary syphilis. More study should be carried out along this line. At post-mortem examinations the spirocheta should be sought for in the heart muscle. If found it would probably explain our causative factor.

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MUTATION OF PULMONARY SHADOWS DUE TO TYPE OF BREATHING

H. A. BRAY, M.D.

New York State Hospital for Incipient Pulmonary Tuberculosis

RAY BROOK, NEW YORK

SOME observers believe that the roentgenogram offers a reliable means for the identification of the pathological changes of pulmonary tuberculosis. This tendency is illustrated by the classification of pulmonary shadows in tuberculosis devised by Cole,* in which a strictly pathological nomenclature is employed. By others such claims are accepted with reserve. These opposing views have made difficult the clinical appraisal of this procedure, and the present communication aims to present certain observations which may prove helpful to the solution of this problem.

The correlation of pulmonary shadows with the pathological changes of tuberculosis presupposes that each of the varied lesions encountered in this disease casts a characteristic shadow on the roentgenogram. According to this view, the shadow for any particular type of lesion remains constant and unchanged. Certain observations, however, would appear to question the validity of this position.

Some years ago, when making a comparative study of a series of radiographs of a patient taken at one sitting, I noted an appreciable difference in the appearance and distribution of the pulmonary densities. Such differences, at first attributed to faulty technique, were discovered, upon further investigation, to be associated with the type and depth of the inspiration employed by the patient preparatory to the *x*-ray exposure. The shadow mutations due to this cause, at times, were striking, and are particularly pertinent to the present discussion.

Stereoscopic plates were made at the height of suspended costal inspiration and again at the height of suspended diaphragmatic inspiration. In a few instances, exposures were also made during tidal respiration, but the contrast with the other films was not sufficiently marked to merit especial attention. Posterior ex-

* Cole, L. G., Interpretation of pathology visualized by the roentgen examination of the chest. *Trans. Nat. Assn.* Study and Prevention Tuberculosis, 1917.

posures were preferred to the usual anterior exposures, because on abdominal breathing the thorax does not remain in contact with the film, owing to the protrusion of the abdomen, thus causing a technical difference which might prove confusing in a study of this nature. Exacting standards were employed in the details of *x*-ray technique so as to obtain uniform photographic results, a requisite for a satisfactory comparative study of the films.

FIG. 1. Costal breathing. Case 4291. The outline of the thorax is relatively short and broad. The heart and diaphragmatic shadows are conspicuous and the shadow projecting from the left hilum upward and outward is dense and sharply defined.

FIG. 2. Abdominal breathing. Case 4291. The outline of the thorax is long and narrow. Mediastinal shadow is elongated. Note the annular shadow proximate to the left hilum, and almost complete disappearance of the band-like shadow in this region noted in Figure 1. The pulmonary shadows in this region are soft in type and in contrast with those in Figure 1, which conform to the hard type of shadow.

On costal inspiration expansion of the lung is manifested by an increase in the circumference of the chest; while on diaphragmatic inspiration the chest remains immobile, and expansion is effected solely by the descent of the diaphragm. The direction in which the lung expands affects its shape. It is relatively short and thick on costal inspiration, but long and narrow on diaphragmatic inspiration. This difference is also evidenced on the films by a similar contrast in the respective outlines of the lung fields. In Figure 1 we may note the relative increase in the width of the upper intercostal spaces and the elevated position of the diaphragmatic shadow on costal inspiration, and in Figure 2 the elongation of the mediastinal shadow on diaphragmatic inspiration. In addition, the position and shape of the cardiac shadow are noticeably changed. The heart is usually drawn to the left on diaphragmatic breathing, owing to the relatively greater descent of the left leaf, with the result that the cardiac shadow occupies a more prominent position in the left lung field than on costal breathing.

Inasmuch as the hila move in unison with the diaphragm, their shadows will appear lower in the lung field on diaphragmatic inspiration, because of the greater descent of the diaphragm with this type of breathing. This change in the position of the hilar shadows may amount to two interspaces or more, and be associated at times with appreciable changes in both outline and density. In Figure 2 there is an annular shadow adjacent to the

left hilum on diaphragmatic breathing, but, as may be seen in Figure 1, this is absent on thoracic breathing.

Of particular interest to the present discussion, however, is a difference in the distribution and mutation of the pulmonary shadows, which may be appreciated best by a comparison of the films on costal inspiration with those on diaphragmatic inspiration. In certain instances, shadows ordinarily termed "hard," and regarded by some observers as denoting fibrosis and inactivity, may be converted into shadows which are "soft" and commonly interpreted as evidence of an active lesion. Thus, the prominent band-like shadow which projects from the summit of the left hilum in Figure 1 has been replaced in Figure 2 by a shadow which is more or less characteristically soft in type. The adjacent shadows also partake of the change, although to a lesser degree. In Figures 3 and 4 the mutation is even more striking, and in Figures 5 and 6, though different, it is still quite evident.

It has been suggested that the film on costal breathing best serves for a pathological interpretation of tuberculosis. This supposition, however, is not supported by any known facts. Moreover, from the foregoing it is obvious that numerous transitions may be obtained in the mutations here illustrated, by regulating the extent of participation of the costal and diaphragmatic elements during the inspiratory act.

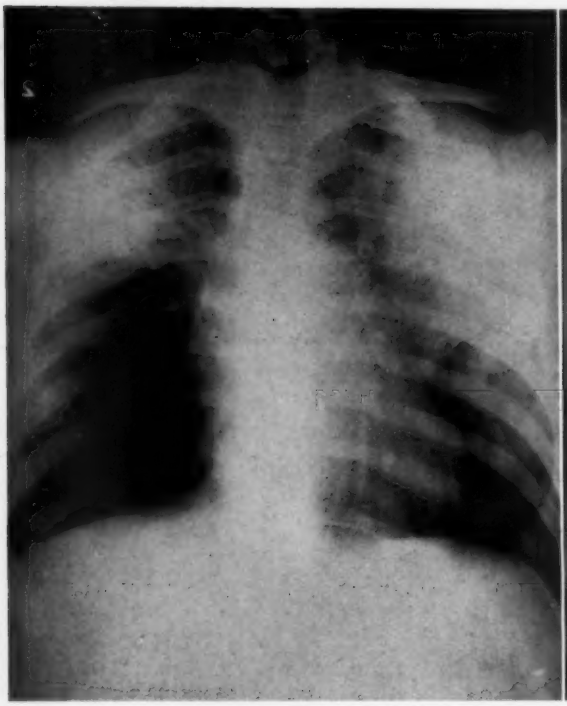

FIG. 3. Costal breathing. Case 6746. Note particularly the dense uniform shadow occupying the outer two-thirds of the second, third and fourth interspaces on the right side, internally fusing with the hilum shadow.

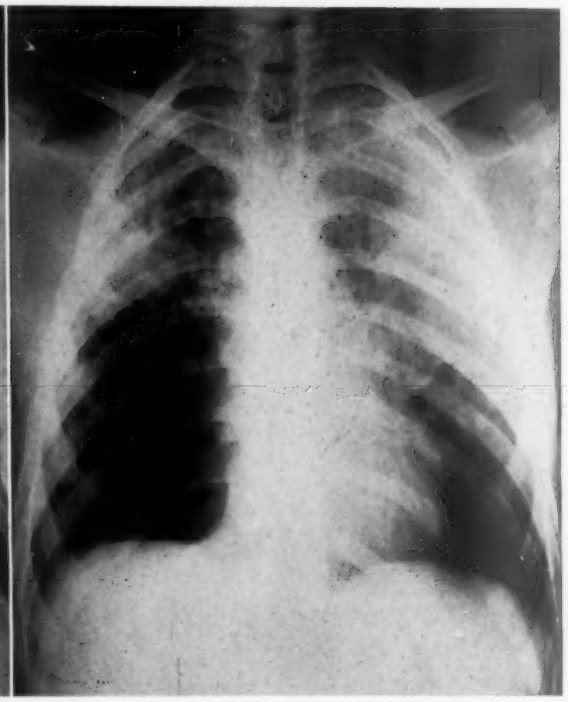

FIG. 4. Abdominal breathing. Case 6746. Note the remarkable change in the location, distribution and appearance of the pulmonary shadows in the upper right lung field. The difference in the outline of the chest on costal and diaphragmatic breathing indicates the difficulty of forming an opinion of the shape of the thorax from the roentgenogram.

The causal factor of these mutations cannot reasonably be attributed to pathological changes within the lung, since the time interval between the *x*-ray exposures was well within a minute. Nor can the difference between the respective volumes of air intake on costal and diaphragmatic breathing be regarded as an important contributory factor, inasmuch as the air intake as registered by the spirometer varied only

from 12 to 20 per cent in favor of costal breathing. That the mutations are associated with the type of respiration was apparently established when it was discovered that the accompanying films could all be readily duplicated by governing the type of respiration. Their presence probably can best be explained by the theory that the *x*-rays impinge on lesions, which, in common with the rest of the lung, have changed their shape with the type of breathing.

A knowledge of the shadow mutations here referred to will prove helpful when attempting to determine the effect of tuberculin injections on the pulmonary lesion, or the progress and distribution of the disease by serial roentgenograms. Their occurrence, however, is especially to be remembered in studies devoted to the correlation of the roentgenography and pathology of tuberculosis.

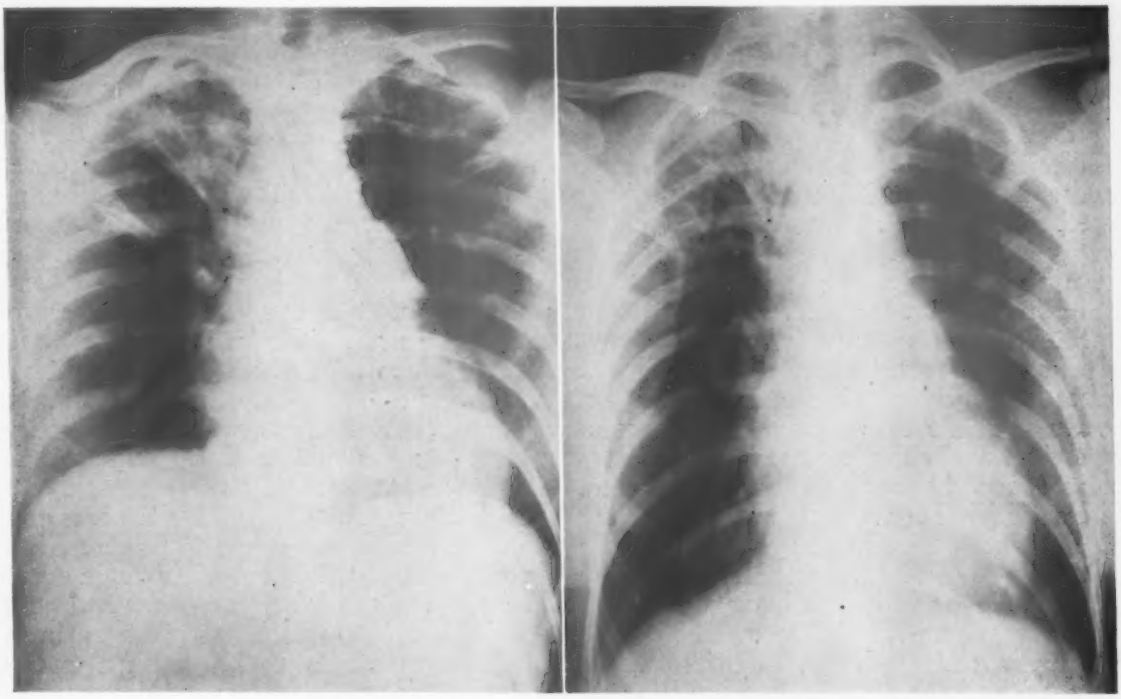

FIG. 5. Costal Breathing. Case 6667.

FIG. 6. Abdominal Breathing. Case 6667.

Figures 5 and 6 are further examples of mutations of shadows due to type of breathing, and in certain respects contrast with the mutations noted in the other figures.

From the foregoing it would seem inadvisable to employ a strictly pathological nomenclature in interpreting pulmonary shadows. It would perhaps be better, at least for the present, to use a terminology descriptive of the pulmonary shadows.

THE ROENTGENOLOGIST AND THE UROLOGIST IN THE DIAGNOSIS OF RENAL DISEASE*

BY E. GRANVILLE CRABTREE, M.D., AND WILLIAM M. SHEDDEN, M.D.

Massachusetts General Hospital

BOSTON, MASSACHUSETTS

GENERAL CONSIDERATIONS

WITH the rapid development of cystoscopy and the roentgen ray, large burdens in diagnosis have been placed on the roentgenologist. Unfortunately for him, he does not have at his command all the clinical facts that exist, to enable him to make the best possible diagnosis. With the urologist, who has the roentgen-ray findings, clinical symptoms and the facts obtained by cystoscopy, the matter is somewhat easier.

Many cases with pathological kidneys are not sent to the urologist early in the investigation. This is as it should be. When they do arrive, frequently gastro-intestinal and complete medical examinations have been made and the renal diagnosis has been not only the last thing to be established, but may even be the last thing suspected. For this reason the roentgenologist is in much closer contact with the general practitioner, whose case is being investigated, and if his knowledge is broad he is the one man in position to give valuable advice, based on his plates, to guide investigation of any particular case. Patients are, I believe, most often sent to the roentgenologist for pain. We all know that in many instances negative roentgen-ray report for stone is interpreted by patients and frequently by the physician as equivalent to no renal disease. Stone is, of course, but one of a number of surgical renal conditions which give symptoms. It has been my experience that the more finished and well-trained the roentgenologist the more careful is his report to the physician on the degree of positiveness or negativeness of the roentgen-ray findings. I would not be surprised if Dr. Holmes' aim in having me, an urologist, address the New England Society of Roentgenologists is not only that a better understanding of the renal problem may result to both of us from a discussion of an urological subject, but, what is more important, benefit accrue to the man who sends in cases for diagnosis. That the patient will benefit to a corresponding degree is a necessary sequence.

What I have said regarding the guidance which roentgenography may give to the general practitioner is not intended in any way to detract from the general man. All of us recognize how simple a difficult diagnosis is, once it is made. We also recognize that a busy practitioner's problems are not those of a special man. His work is essentially made up of many short visits and a great deal of night work, and it is done under surroundings in which there is neither time nor equipment at hand for a thorough study of each case which is presented to him. Medicine is now so complex that he cannot be expected to keep posted on all the possibilities in every branch of medicine, surgery and the specialties. The roentgenologist is in a position to make to these men many valuable suggestions in the diagnosis of renal conditions, and these suggestions are gratefully received.

Routine examinations of the kidney and ureter regions have two essential purposes, one, to show suspicious densities which, from the roentgenologist's experience, he is led to believe lie within the region of the kidneys and the ureters. He is certainly entitled to make a statement as to whether he thinks these are stone, tubercular calcifications, calcified mesenteric glands and phleboliths. Yet all these conditions may be absent and the kidney still be pathological. This means that he is entitled also to make estimate as to the normalness of the kidney in size and position. On this depend many diagnoses. It is my aim to discuss the group of kidney diseases in order that the roentgenologist may better

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judge of the possibility of abnormalities from the data shown by roentgenograms. A roentgen-ray examination of the kidney regions is unsatisfactory if it fails to show definite outlines of the kidney shadows. This is a point of much significance, and justifies repeating the examination. False leads in diagnosis result from poor demonstration of renal outlines.

PROBLEMS OF THE UROLOGIST IN WHICH X-RAY OF THE KIDNEY IS CONCERNED

Briefly, the clinical pathology of the kidney comprises tumors, stones, infections, stasis or any combinations of these four.

TUMOR

To the urologist as well as to the roentgenologist, tumor must be considered to mean the differential diagnosis of masses occupying the sites of one or other of the kidneys. From these the urologist with the help of the roentgenogram sorts out the true renal tumors and frequently gives valuable aid in the diagnosis of spleens, liver abscess, psoas abscess, fatty retroperitoneal tumors, etc. True renal tumor, usually hypernephroma, is of course recognized by enlargement of the kidney shadow if enlargement exists, and deformity, by pressure of the pelvis of the kidney as shown by pyelogram. This deformity follows no set rule other than that it is the demonstration of a new growth encroaching upon some portion of the pelvis. It must be remembered that the tumor may arise from the extreme upper or lower pole of the kidney, and may increase to great size without deforming the kidney more than in the upper or lower calices against which the tumor presses. Papillomatous growths of the renal pelvis are more difficult to diagnose, particularly when bleeding occurs, giving rise to retained blood clot. Other forms of tumor in the region of the kidney, particularly retroperitoneal growths, are apt to carry the kidney and ureter out of position either toward or away from the midline. In all these conditions the position of the kidney and ureter can be made a landmark for differential diagnosis.

In polycystic kidney the characteristic renal deformity is elongation of the pelves and calices due to occurrence of multiple cysts, among which, by the growth of the cysts, the normal calyx is drawn out as well as pressed upon. Compression of the kidney from enlargement of Riedl's lobe of the liver may actually deform the pelves of the kidney in such a way as to make it extremely difficult to differentiate

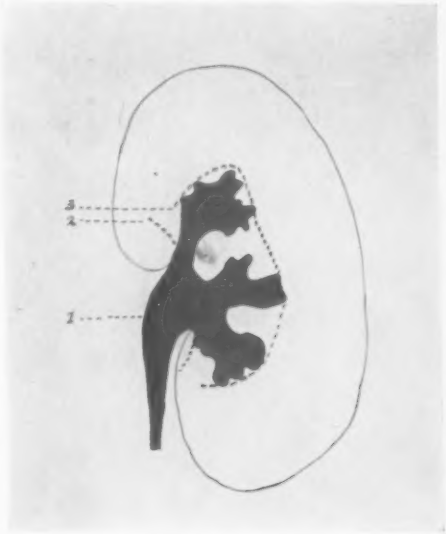


FIG. 1. Diagram of an injection of the pelvis in which a line (3) connects the tips of the pyramids. Abnormalities in outline of the pyelogram beyond this line are usually due to inflammatory processes in the kidney substance. Tuberculosis and staphylococcus type of abscesses may appear in this area.

between that and true tumor of the kidney. Cystoscopic examination usually will show this pelvis to be normal in capacity.

STONE

The demonstration of large stones in the kidney has at this stage of roentgen-ray diagnosis become easy. It cannot be too frequently emphasized to the medical profession at large and especially to some surgeons, that the kidney is the important thing, not the stone. I mention this merely to indicate that the demonstration of large stones in the kidney is not a complete diagnosis of a kidney condition. It is important to know whether the kidney is worth preserving, or, if it should be extirpated, whether its fellow is capable of supporting life. The nature and extent of dilatation associated with stone is a guide to subsequent usefulness of that

kidney. It is also important to have these facts determined *before* operation. One discouraging feature of urological work which still persists is that cases are still sent to us for diagnosis *after* the operation has already been performed for the supposed condition. It is also important to have generally recognized the fact that a kidney which is worth saving if its stones

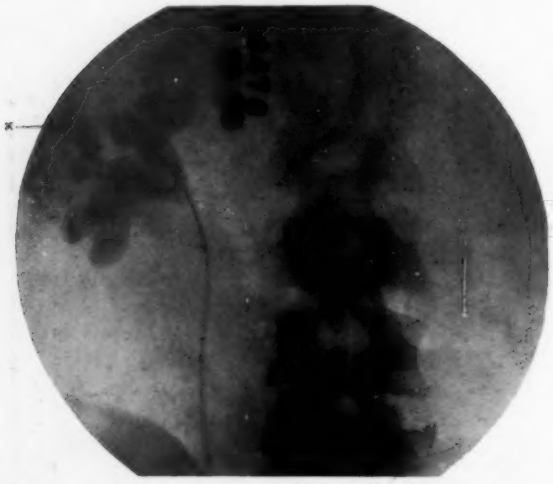


FIG. 2. Hydronephrotic kidney with bacilluria indicating pyelitis, almost no pus, and high temperature on that account. Pyelogram showed a triangular area in the cortex which suggested cortical suppuration. Four days following the pyelography, patient voided on three occasions bloody, pussy urine, which contained large numbers of staphylococcus aureus after which the urine cleared up except for the pyelitis. The temperature dropped to normal and the patient quickly recovered. I believe there has been a focus of suppuration in the kidney, at the point indicated in the illustration, which produced an abscess that ruptured into the pelvis and produced satisfactory drainage.

are removed, often has not proved so in the end, because of failure properly to clean up the pelvis which has recently harbored a stone in order to free it from pus and put it back into shape to perform the work expected of it. At this date it is unpardonable surgery to do nephrectomies and removal of calculi by pyelotomy and nephrotomy without having at hand full data regarding the condition of the kidney which harbors the stone. It is equally unpardonable to remove a stone and to leave an embarrassed kidney with active infection, alkaline urine and stasis, all conditions which contribute to recurrence of stone, and part of which conditions can be removed by proper postoperative treatment, thus considerably diminishing the chance of recurrence. There are patients now living comfortably on kidneys which at the time of operation seemed hopeless. These patients have later been forced to depend entirely upon a damaged kidney, because, subsequent to operation, stone and severe infections have completely

FIG. 3. Illustration of a kidney with multiple staphylococcus abscess in the cortex. Two of these are well down in the papillae and deformed the neighboring calices. One of these abscesses eroded through an arcuate artery producing serious hemorrhage for which nephrectomy was done. These two areas showed as pyramidal pale areas similar to that shown in Figure 2, and were in exactly the positions of the two abscess areas mentioned.

destroyed what was previously the sound kidney. The ability of these kidneys to return to function is nothing short of marvellous. Yet, if leaving them must mean recurrent stones and repeated operation (which it does not), it places too great a burden upon the patient.

The one place where diagnosis of stone still remains difficult is in the demonstration of large or small stones which, because of their composition, fail to show in the roentgenogram, and of small stones, either within the pelvis or the ureter, which, because of their size and the size of the patient, are shown with difficulty. We have come to discover that there are a few cases of slight dilatation of kidney pelvis or ureter with or without infection and negative roentgenograms for stone, in which there is no demonstrable cause for dilatation of the pelvis. These dilatations

are sometimes due to a small stone which we can either stain by injecting the pelvis, or show as a rarified area in the pelvis, or demonstrate in the ureter by blocking of the ureter. The wax-tipped catheter is most useful, of course, in the ureter. In many instances symptoms will guide us in suspecting the presence of these stones. The wax-tip is not of such great reliability in the pelvis where stones may exist in the calices and be unrecognizable by this method.

INFECTIONS

Within the past two years some advance in our conception of the significance and of the treatment of infections has taken place. I prefer to consider infection under three classes: 1. The pyelitis type, which is usually due to the colon bacillus. 2. The staphylococcus type, commonly and erroneously known as "hematogenous infection," in which abscess development takes place. (This type includes perinephritic abscess because of the renal origin of perinephritis.) 3. Tuberculosis. Roentgenogram and pyelogram can be made to play an important part in the diagnosis of all these three types of renal infection. Recent investigations tend to show that persistent pyelitis is a persistent infection because of renal damage of some form, usually malformations of the kidney or acquired damage from obstruction. For this reason an infection which has persisted for two or more years either as recurrent attacks or as a persistent pyuria can be suspected to be due to some form of renal pathology in addition to simple pyelitis. The cause may be stricture, aberrant vessels, congenital malformations, or, commonest of all, sagging kidneys which have obstruction to the free outflow of urine, particularly during periods when the patient is in an upright position. In these cases roentgen-ray demonstration of the position of the kidney in full inspiration or when standing, is of great value in determining whether further investigation is apt to divulge something of importance in that kidney. Not all sagging kidneys produce symptoms or have stasis in the pelvis. It is the problem of urologists to study this type of case and determine whether or not stasis exists. Cure of these cases is possible, sometimes by operative procedures, in many instances by proper cystoscopic and other measures. It must be recognized that the cystoscope is an instrument for treatment as well as for diagnosis.

I do not recognize any definite peculiarity in the pyelograms in pyelitis which seem to me infallible for determining from pyelogram alone whether the pelvis of the kidney is the seat of infection. In some instances there is broadening of the calices in long-standing infections of the pelvis, but I have seen long-standing pyelitis where there is normal cupping of the calices of all portions of the pelvis.

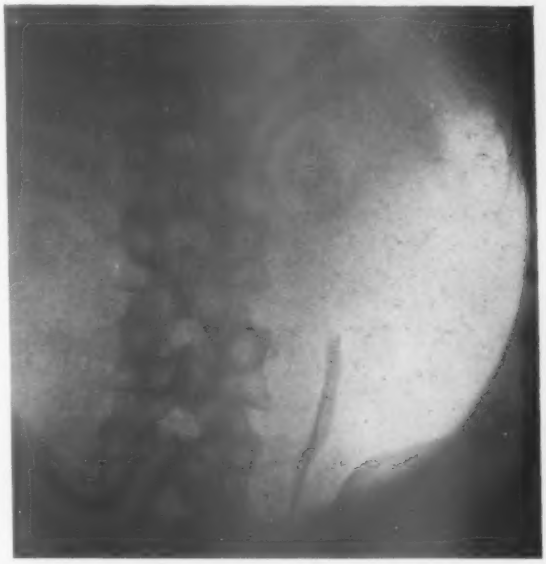


FIG. 4. Ureterogram with catheter in the ureter demonstrating a uric acid stone in the ureter. The stone appears as a rarefied area in the injection fluid.

Urologists now are on the watch to recognize mixed infections with pyelitis symptoms in which the kidney shows a true pyelitis and, in addition, cortical sepsis with abscess formation. These cases, on pathological examination, show the abscess to be due to pyogenic types of bacteria and not to B. coli. We have studied the so-called "hematogenous kidney" pyelograms to determine whether it is possible to recognize abscesses in the cortex or the pyramids of the kidney. The result has not been totally satisfactory. It is possible, however, to recognize in

some cases definite areas in which the injection material in the neighborhood of the calices is either flattened or extends into the cortical substance. These abnormalities have been proved to be the sites of abscesses usually situated in the pyramids. I believe in great measure the success of pyelography in these cases depends on one of two things; either upon the presence of an abscess cavity which can be filled with injection material, or a swollen papilla which encroaches upon and flattens the neighboring calyx. These areas of necessity lie in a portion of the kidney outside of a line including the tips of the calices, when seen in the pyelogram.

In tuberculosis actual calcification of a portion or the whole kidney may show in the roentgenogram. Most tubercular kidneys do not have calcification. In those the pyelogram is apt to be of help in diagnosis by showing irregular extensions of the injection material into the kidney outside of the line of the calices above referred to. Irregular granular calcification in the kidney should lead one to suspect tuberculosis in these cases. There is an occasional cortical stone formed within the substance of the kidney, often in a malformed pelvis or calyx, which must be differentiated because it lies outside the line of the calices. Usually differentiation is easy because of the clean-cut dense shadow which the stone shows. In perinephritic abscess, if large, the pyelogram may be of help, although usually it is not needed. A normal kidney pelvis and ureter will be pushed either toward or away from the midline by the mass of pus near the kidney.

FIG. 5. Pyelogram of a kidney with the catheter in place. Kinking is almost entirely absent. There is a suggestion of an irregularity at the junction of the pelvis and ureter. In this instance the stiff ureter catheter has almost completely obliterated the kinks in the ureter.

FIG. 6. The same case as that shown in Figure 5, showing kinking of the ureter on full inspiration. This kidney has definite stasis as determined by cystoscopy.

STASIS

We believe that something can be gained in our conception of pelvic dilatations by classification of stasis into four types, namely, acute stasis, subacute

stasis, intermittent stasis and what, for want of a better term, I shall refer to as relative stasis. Acute stasis means acute obstruction to the outflow of urine from the kidney from swelling, as in severe pyelonephritis, obstruction from a stone passing down the ureter or, not uncommonly, from a blood clot which fills the ureter and pelvis. These cases are more apt to be seen by the urologist than the roentgenologist because they are in the nature of emergencies. The important thing to be considered is, however, that the obstruction is acute and if relieved, results in no damage to the kidney. The second form of obstruction is that of weeks' or months' duration, due to obstruction to the outflow of urine from the kidney from obstruction to the ureter. The commonest form of this obstruction is renal back pressure in pregnancy and slow-moving stone. The urologist recognizes in these types of obstruction a condition which if relieved is apt to be followed by a return of the kidney to almost if not completely its previous condition. For example, a pyelitis of pregnancy with a 350 c.c. pelvic capacity determined during the pregnancy, is apt at the termination of pregnancy to decrease to 15 c.c. or even to normal.

The third type, intermittent stasis, is perhaps commonest and most difficult to diagnose. The usual occurrence is in the sagging kidney. The amount of damage which results to the kidney is not great. Dilatation takes place, but occurs slowly because obstruction does not persist throughout the twenty-four hours. Recognition of this type of obstruction depends chiefly upon the cystoscope to demonstrate stasis, and upon the pyelogram to show what is the nature of the obstruction. Inasmuch as these cases are accompanied by slow dilatation of the pelvis with persistence of pelvic and ureteral peristalsis, they are not often large, but can be considered to account for a great number of the painful kidneys. These pelves may or may not be the seat of pyelitis in addition. By correction of these we may both relieve pain, and cure long-standing infections. I feel like repeating the statement which I have already made, that because a kidney is low and the course of its ureter is not straight, that kidney must not be considered to have stasis until it is proved so through cystoscopy. Another type of intermittent stasis in the kidney is that in which there is a ball-valve stone which drops into the ureteral orifice for a time, and becomes dislodged, only to drop back again at a later date. The fourth type of stasis, which we call relative stasis, is not so clear in its explanation or etiology. By this term I refer to those kidneys which apparently show little or no effects of back pressure through flattening of pyramids, yet in which the pelvis and the whole of the ureter as well as the ureteral orifice are dilated. This dilatation is, as far as I know, totally unexplained. Unless the kidneys are infected the symptoms are negative. When infection takes place they are difficult and unsatisfactory to treat.

GENERAL CONSIDERATIONS IN THE PRODUCTION OF GOOD ROENTGENOLOGICAL RESULTS

There are certain pitfalls to diagnosis, both from the point of view of the urologist and the roentgenologist. The common ones you all recognize and they need not be mentioned here. There are a few general points which I wish to mention because of their bearing on diagnosis of renal conditions.

One of these is frequent bilateral dilatation of kidneys or hydronephrosis where only one kidney gives symptoms. So common has been this finding since the introduction of bilateral pyelography as a routine at the Massachusetts General Hospital, that the urologist hesitates to do radical operations on a kidney for hydronephrosis without bilateral pyelography. The probable reason for this is that conditions which produce hydronephrosis on one side, whether congenital or acquired, are apt to be reproduced on the other side. In many instances the acutely painful kidney is the smaller of these hydronephroses and is apt to be the one which is undergoing a dilatation similar to the spreading hernia ring, and is painful. The other one, which has dilated to such an extent that peristalses are lost, does not produce pain at all.

Another point is that from examination of a great number of roentgenograms, I expect to find that there is a similarity of

design and arrangement of calices of the pelvis in the two kidneys. I mean by that, that if one kidney has an extrarenal type of pelvis, the other probably has an extrarenal type also, or a bilateral intrarenal pelvic combination exists. I do not remember having seen an intrarenal pelvis on one side and an extrarenal pelvis on the other.

I have already mentioned the significance of the failure of a kidney shadow to appear in a good plate. If a kidney shadow is persistently absent in clear plates, one of four possibilities must be suspected: nephrectomy, congenitally small kidney, congenitally malposed kidney or hydronephrosis. The hydronephrotic kidney is particularly apt to show indistinctly or not at all, because the cortical substance is extremely thin as a result of prolonged back pressure.

I have already referred on several occasions to the value of the cystoscopic estimation of capacity of the pelvis. This is simply done and has a bearing on diagnosis. Hydronephrosis and congenitally small kidneys are easily recognized.

In addition, it is possible to recognize stasis in these cases of sagging kidneys already mentioned, by determining whether or not the pelvis is filled to capacity at the time cystoscopy is done. A small kidney pelvis of 15–20 c.c. capacity when full to its capacity at the time of cystoscopy, is just as definite an instance of stasis as when a large hydronephrosis is found with many times the same amount of urine in it.

Where double ureters exist and enter the bladder it seems to be a rule that the lower orifice, as seen by the cystoscope, enters the upper pelvis of the kidney and the upper orifice in the bladder connects with the lower pelvis in the kidney. In instances in which a small pelvis is seen to occupy a half of a normal-sized kidney shadow, and in which one ureter is found entering the bladder, the roentgenologist is entitled to ask the urologist for an ureteral injection, because it is probable that a Y ureter exists, only one branch of which has been catheterized.

In gastrointestinal roentgenograms instances are found in which no definite kidney shadow is seen, but in which the intestines full of bismuth seem to be pushed well away from the kidney region. One should suspect large hydronephrosis in these cases.

Occasionally the persistent presence of gas in the intestines over one kidney region will give a lead as to renal pathology. In inflamed condition of the kidney the persistence of gas over the affected area on repeated examinations is sometimes seen.

It is unsafe to consider a pyelogram negative for kinking of the ureter when the pyelogram is made with a stiff catheter passed into the pelvis of the kidney. A stiff catheter will straighten out kinks in some instances to such an extent that they will be hardly recognizable. If a portion of the injection fluid is withdrawn from the pelvis and the catheter pulled down to the brim of the bony pelvis the ureter can then be injected and any kinks demonstrated. Ureterograms for the demonstration of kinks should be taken with the kidney in complete downward excursion produced by a full inspiration, or by standing the patient upright. The ureter catheter is obstructed in the ureter by kink as well as by stone. The cystoscopist suspects kink in those cases in which the ureter catheter is gradually moved by manipulation through certain portions of the ureter.

Reports from the roentgenologist to the general practitioner as to the normal appearance of pyelogram in the sagging kidneys should be given out with some hesitation when the symptoms for which the examination was made are pain or infection. In these cases cystoscopic evidence of the presence or absence of stasis is necessary for diagnosis.

Ureterograms are made with less discomfort to the patient if the pelvis is emptied of fluid by suction before the catheter is drawn down into the ureter. The ureter can then be injected without overdistention of the pelvis.

I have not had experience with pneumoperitoneum and air injection of the pelvis and ureter in renal investigations, sufficient to allow me to discuss their value. The error of diagnosis in renal conditions under the procedures by which we work is less than 2 per cent.

SERIAL ROENTGENOGRAPHIC OBSERVATIONS OF CHRONIC PULMONARY TUBERCULOSIS*

BY J. BURNS AMBERSON, JR., M.D.

Loomis Sanatorium

LOOMIS, NEW YORK

TODAY the roentgen ray is an indispensable aid and guide in the intelligent study, diagnosis and management of pulmonary tuberculosis. This is a truism, but many repetitions will be required before an unjustified though much too prevalent skepticism will give way to its unanimous recognition. It is proper occasionally to take time to appraise the various modes of examination at our disposal, but it is fruitless to enter into hairsplitting debates on the relative merits, for instance, of two such diverse methods as auscultation and roentgenography; it is much more profitable to appreciate their interdependability. Once we have acquired a clear conception of the limitations of roentgen-ray findings, the distinctly unique advantages of these findings, and their wide applicability as a supplement to other clinical, physical and laboratory data, we shall have surely struck the path of progress. There is much to be said about roentgenography and roentgenoscopy in the early diagnosis and the differential diagnosis of pulmonary tuberculosis, but this discussion will be confined to a consideration of structural changes in established lesions and of certain inferences that can be drawn from the observation by serial roentgenograms of these changes. There is no problem which roentgenologist and clinician can attack jointly to greater mutual profit. The phases of the problem are manifold. It is of utmost interest simply to trace the evolution of the tuberculous lesion through its varying periods of progression and retrogression; such a study alone divulges much information that the pathologist for generations longed for but did not find. But it is even of more value to correlate anatomical mutations with clinical symptoms. If the day comes—and I believe it will—when we can state with a fair degree of accuracy what clinical manifestations should accompany a given anatomical change, we shall have gone a long way toward surmounting obstacles that now beset our course. If it is admitted that cellular as well as humoral reactions play their part in tuberculo-immunity, it becomes self-evident that the roentgen ray must play an essential rôle in depicting gross anatomical alterations that accompany the ebb and flow of that ill-defined element called resistance. Tuberculosis most often attacks the lungs and, fortunately, it is here that a combination of physical properties enables us to study anatomical reactions more closely than in any other body tissue.

At the Loomis Sanatorium our investigations of structural changes in the lesions of pulmonary tuberculosis have thus far been to us most fruitful. The field is vast, and should tempt the roentgenologist to join hands with the clinician in further research.

In the present stage of our knowledge it will serve no purpose to speculate on the roentgenographic characteristics of pulmonary tuberculosis in its true incipiency. Certainly there is a transitional stage between a slight lymph-node involvement and gross parenchymatous lesion, in which stage the roentgenogram cannot be expected to decide whether or not there exists the beginning of clinical disease; it never will decide, because the truly incipient change is microscopic. Passing, therefore, to the definitely recognizable early parenchymatous lesion, certain characteristic shadows present themselves. The appearance is variously described as mottling, cirrose clouding or cotton ball shadow. Its center is its densest part, and its periphery is hazy and indefinite, shading off imperceptibly into normal lung markings; the peripheral haze may be narrow or it may extend through a wide

* Read before the NEW ENGLAND ROENTGEN RAY SOCIETY, Boston, Mass., March 11, 1922.

area. These are the fundamental earmarks of the conglomerate tubercle with its collateral inflammation. I would stress collateral inflammation because it is usually the unique accompaniment of tubercle that is chronic.

Here we may pause to establish clearly in our minds the concept that chronic tuberculosis of the adult represents disease developing, not in virgin soil, but in a soil the reactions of which are altered by some previous sensitizing dose or doses of bacilli. Moderate or massive infection of an experimental animal that has previously developed a relative immunity through a nonlethal dose of bacilli is always attended by a rapid inflammatory reaction characterized by more or less grave constitutional symptoms and the pouring out of inflammatory products—cells, serum and fibrin—about the focus of infection. Krause has repeatedly emphasized that this response is not elicited by a moderate initial infection of a healthy animal; it is distinctly a response of allergic tissue. In the human adult the exudative reaction has been variously described as collateral inflammation, perifocal pneumonia and collateral hyperemia; the term collateral inflammation or perifocal inflammation is preferable because the reaction is not specifically pulmonary, but occurs wherever the bacillus is implanted in allergic tissue. This is the reaction that underlies the perifocal or collateral haziness in the roentgenogram. On the basis of this concept it is readily understood why the haziness may be of greater or less extent, varying with the intensity of the allergic response.

In this early stage there may appear changes in distant structures, notably the hilum. Its outline may become indistinct and hazy and accentuated trunks may lead to it from the pathological focus. This is to be explained by the fact that the hilum is the point of confluence of the pulmonary lymphatics and its lymph-nodes react with the same perifocal inflammation as they filter out the products of disease that surely drain through them. Our previous studies have indicated that the hilum is often a dependable index of the state of activity of the pulmonary process; as this process advances the hilum becomes progressively more puffed up and indefinite in outline, and as healing follows, the structure regains much of its original contour and sharpness of definition. The process is more striking when the mottling has not encroached upon the hilum.

In the literature and elsewhere much discussion centers on the diagnosis of activity of pulmonary tuberculosis by means of the roentgenogram. From a single observation one can often offer the opinion, "disease probably active or recently active" or "disease probably stationary or retrogressive," but for him who from such an observation positively diagnoses activity or inactivity there lies ahead an inevitable and humiliating disillusionment. From the roentgenographic point of view there is only one sure criterion of activity, and that is the demonstration by serial roentgenograms of an actual progression of the pulmonary mottling with or without increased rarefaction, interpreted as advancing cavitation. To be sure, this is merely an anatomical change, but I have never seen such a change without clinical manifestations. If we could be absolutely sure that all technical and physical factors were constant, it would be possible to depend on an increase in perifocal haziness as an indication of focal activity, but without this condition such a criterion can be deceptive.

Progressive destruction by chronic pulmonary tuberculosis consists in an increase and a coalescence of the mottling, advancing usually from apex toward base and from periphery toward hilum. Increasing density implies caseation with or without fibrosis, and in chronic progressive disease it is usually only a question of time until the dense shadows of caseation acquire a moth-eaten appearance implying beginning cavitation. These small areas of rarefaction gradually merge with one another, forming one or more large cavities. The older the cavity, the cleaner and less ragged it looks, and the more likely it is to assume the form of a sphere or a closely allied geometrical figure. Rarefaction typically begins in an upper lobe near the periphery and, like mottling, advances downward and inward. Destruction may be slow, when it is almost always associated with progressive fibrosis,

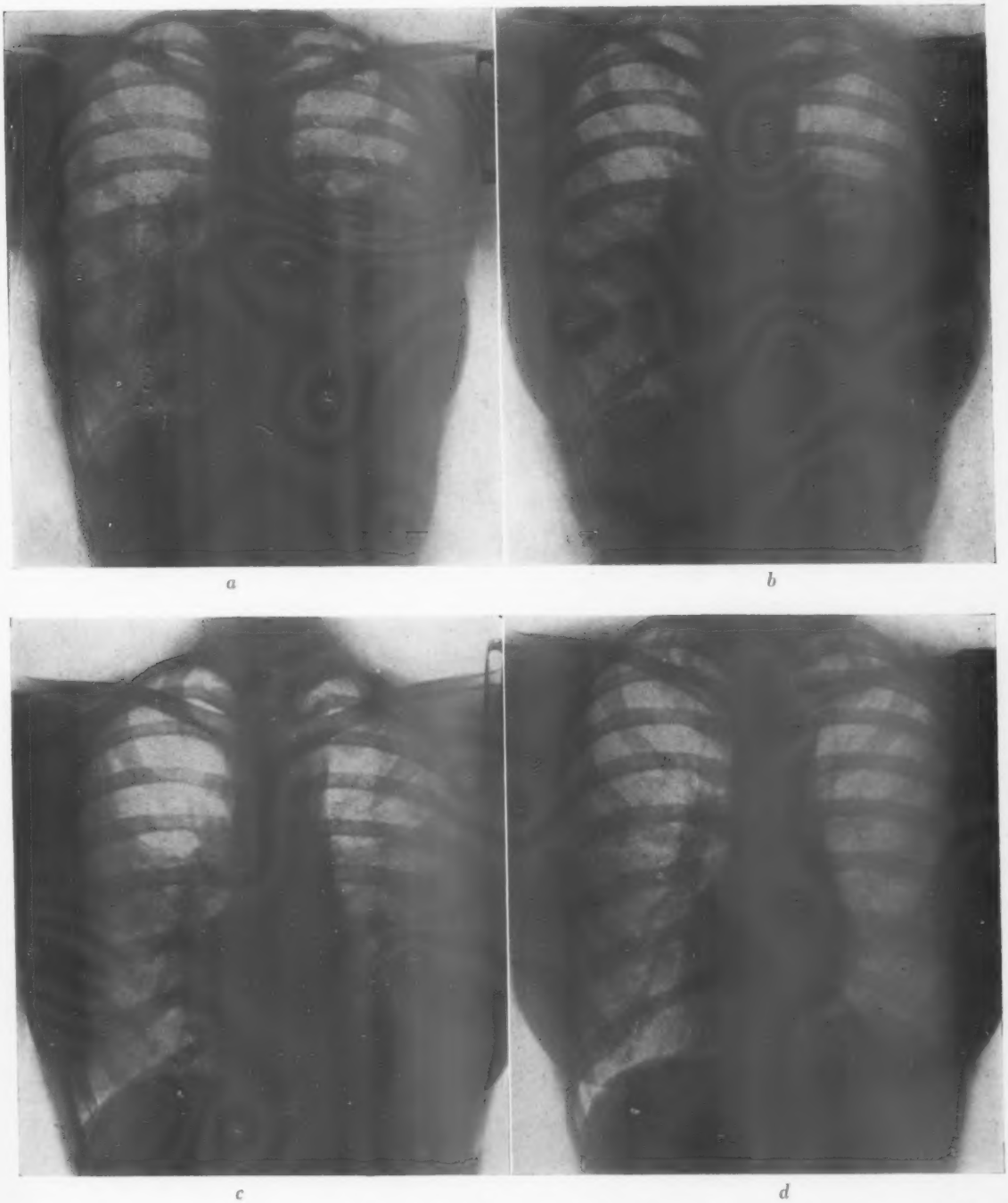


FIG. 1. Time interval between *a* and *b*, 5 months; between *b* and *c*, 9.5 months; between *c* and *d*, 24.2 months; total, 38.7 months.

(*a*) Heavy infiltration, mostly perihilar in lower half of right lung; lighter infiltration on left. Patient had symptoms of active tuberculosis, including fever; sputum, 136 grams daily; numerous tubercle bacilli present. (*b*) Process more marked in both lungs with possibility of small pleural effusion on right. Between *a* and *b* symptoms of activity persisted with gradually lessening severity; tubercle bacilli still present in sputum. (*c*) Clearing of mottling with pleural thickening and beginning fibrosis on right. Symptoms between *b* and *c* improved uninterruptedly; sputum scant; tubercle bacilli disappeared from sputum two months before roentgenogram *c* was made. (*d*) Continued anatomical repair; remarkable clearing with restoration of definite hilum outline and only a few residual deposits in the lungs. Patient remained well; occasional scanty morning sputum, negative for tubercle bacilli.

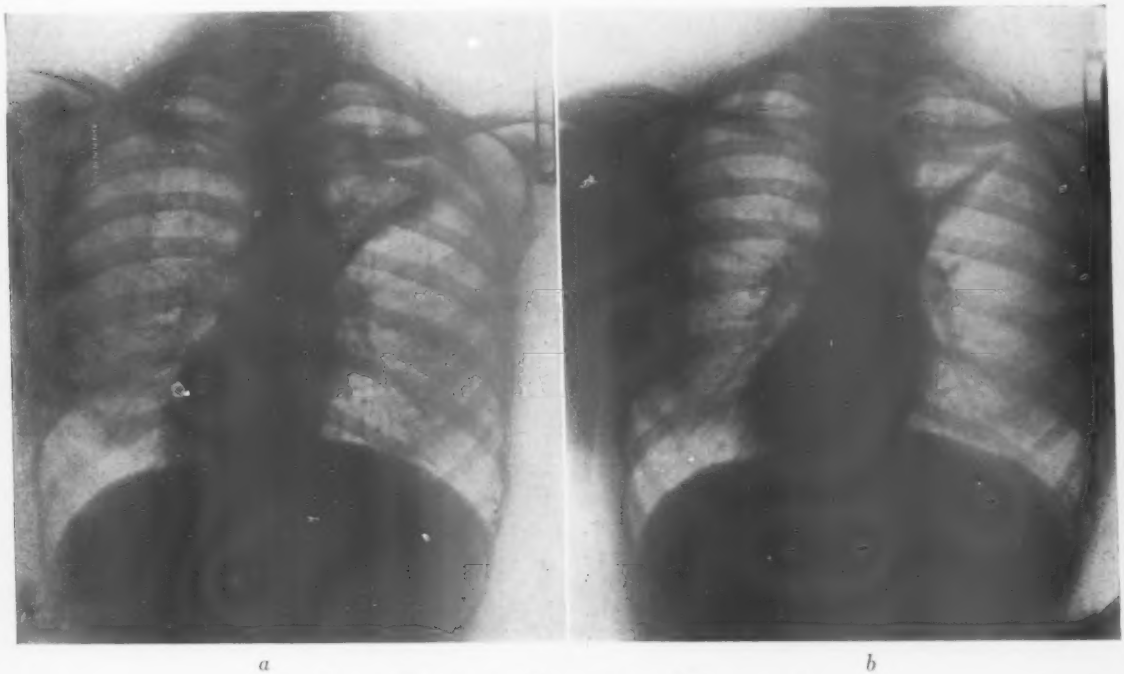
or it may be rapid, when fibrosis is not demonstrable, mottling is densely confluent, collateral haziness is heavy and rarefaction is multiple, thin-walled and ragged. In the rapid type, the patient usually is overwhelmed by toxemia and dies with considerable intact lung tissue; with slowly progressive disease and less toxemia life may last when the roentgenogram reveals surprisingly little sound tissue. In the latter type, as might be expected, the patient may suffer severe dyspnea in spite of feeling otherwise fairly well. With progressive mottling without rarefaction the sputum is usually scant and may be negative for tubercle bacilli for months; when rarefaction of previously dense mottling appears and progresses the sputum increases in quantity and tubercle bacilli are almost always found. In both instances symptoms of toxemia sooner or later appear in definite form. Anatomical repair may become initiated at any stage of the disease, but is less likely to ensue when serial roentgenograms demonstrate the rapidly destructive lesions described above.

a *b*

FIG. 2. Time interval between *a* and *b*, 13.7 months.
(*a*) Moderate disseminated infiltration of right lung, most marked about the hilum; light perihilar deposits on left. Patient recovering from recent symptoms of active tuberculosis including hemoptyses and fever; sputum, 41 grams daily; numerous tubercle bacilli present. (*b*) Clearing of mottling with restoration of definite hilum outline. Patient free of symptoms except for scant expectoration; tubercle bacilli absent for 7 months.

The first phase of repair is clearing of mottling; and by this is meant the disappearance of perifocal inflammation. The explanation has its basis in the concept of allergic reaction to which we have already referred. In the experimental animal that survives the initial exudative reaction following infection, the anatomical products of inflammation disappear, a sharply defined tubercle appears and the animal passes into a chronic, slowly progressive type of disease. In the lung of the human relatively immune adult, therefore, it is to be anticipated that repair will start with a similar resorption of perifocal inflammation to be detected roentgenographically by a clearing of perifocal haziness. In some cases this clearing can be discerned within a period of three or four weeks, and in many it is quite pronounced at the expiration of two or three months. Shadows, the outlines of which seemed previously to be obscured by a more or less dense fog, now stand out clearly as if the fog had been blown away. In many instances the conglomerate tubercles appear with such clarity that

they can be counted under the stereoscope. Haziness, clouding and poor definition give way to discreteness, compactness and discernible delimitation. If there is no complicating involvement, tuberculous or nontuberculous, of any other organ or tissue, the patient practically always shows clinical improvement with gain in weight, lessened toxemia and decreasing cough and expectoration. The presence of cavitation may alter conditions considerably, and of this I shall speak presently.



a *b*

FIG. 3. Time interval between *a* and *b*, 12 months.

(*a*) Heavy infiltration upper part of right lung; limited below by band of fibrosis, partly interlobar. Vague constitutional symptoms including malaise and malnutrition; no sputum (tubercle bacilli present in sputum 4 months previously). (*b*) Clearing of mottling with upward contraction of the affected region, secondary to fibrosis; deflection of mediastinum. Progressive improvement in constitutional condition; no local symptoms, except for slight dyspnea on exertion.

Once the perifocal haziness has cleared, we assume that the residual shadow represents the conglomerate tubercle proper, divested of its initial enveloping inflammation, and that healing from this stage proceeds by the deposit of fibrous tissue. Within two to six months this deposit can often be found in serial roentgenograms. Gradually, through the next one or two years the individual conglomerations are seen to shrink and their granular texture is replaced by a homogeneous cloud with sharply defined edges. The shadow can no longer be described as mottling or cirrose clouding, but its characteristics are probably best conveyed in the term discrete uneven clouding. Occasionally one loses all trace of the shrinking tubercle; from the roentgenographic point of view it has been entirely resorbed. But it is a rare tubercle that does not leave behind some slight vestige in the form of a little uneven clouding with or without a thin, sharp, dense line extending from it to the hilum. At this point the markings may be permanent; I have observed these fibrotic densities unchanged after a lapse of eight years.

If there is one roentgenographic feature of healing pulmonary tuberculosis more prominent than another it is localization. Often a series of pictures will vividly portray nature's effort to seal off from sound tissue the pathological focus. Along the course of fuzzy, poorly defined, accentuated trunks radiating from the hilum this change can best be traced. Slowly the trunks become more compact and sharply defined until they are transformed into

wiry rays most prominent at the lower border of the upper lobe lesion. Coincidentally a network of tangled striations becomes interwoven with these fibrotic trunks, and over all a light cloud of diffuse fibrosis is thrown. If healing continues from this point, contraction of the lesion is inevitable, and it is not uncommon to see the process sharply confined above the first or second intercostal space where, one or two years previously, its ill-defined lower margins reached the third or fourth.

The presence of cavity in the healing lesions influences conditions anatomically and clinically. It has been indicated that, beyond certain limits, the older the cavity the less ragged and the better formed it is, implying, of course, that its wall is more or less fibrotic. The progress of excavation is retarded only when the roentgenogram shows the formation of enveloping fibrosis. Otherwise, it usually continues in its course of unbridled destruction. Caught in the meshes of striations described above and overlain with fibrotic cloud, the cavity usually shrinks, and occasionally it becomes completely obliterated. Even as shrinkage proceeds there may be a coalescence of multiple areas of rarefaction, and we visualize a twofold healing process, a cleaning within and a contraction without. As might be expected, contraction of cavity is not seen until fibrosis is fairly well developed; consequently it requires a long time.

Healing by fibrosis of the lesion in which cavitation cannot be diagnosed in the roentgenogram always is accompanied by improvement in the clinical condition, provided other complications do not interfere. Weight is gained, temperature and pulse become stabilized, cough and expectoration disappear and tubercle bacilli, if they have been present in the sputum, are usually no longer demonstrable. From this class come the bulk of the patients who are discharged from treatment with "disease arrested." When a solitary cavity becomes obliterated similar symptomatic improvement can be expected. But when cavity persists, even though contracted, conditions are usually altered; constitutional improvement may be marked, but in a majority of instances expectoration, though reduced in quantity, will continue to appear and it will be positive for tubercle bacilli. To such patients we often say, "Your disease is quiescent and healing, but for years to come, perhaps for the remainder of your life, you will likely have a little sputum containing tubercle bacilli." There is also an extra hazard in such cases in the liability to small or large hemoptyses, often resulting in a bronchogenic dissemination of the disease with fatal issue. Aside from this potential danger it must be remembered that persisting cavity is usually a constant source of bacilli-laden exudate, capable at any time of infecting other parts of the lungs and possibly responsible for more remote complications such as laryngeal and intestinal tuberculosis. As a matter of fact, our serial roentgenographic studies indicate that tuberculous complications are by all odds most frequent where infiltration with cavitation is progressive. They are less frequent in the cases showing progressive healing of the pulmonary lesion, but an outstanding observation is that complications in this group are more likely to occur where cavitation remains patent even though partially contracted.

Little need be said about calcificaton, because it plays only a small part in the healing of chronic pulmonary tuberculosis of adults. Opie, in his recent work, has considered caseation or calcification within the lung accompanied by similar deposits in the regional lymph-nodes as presumable evidence of primary focal tuberculosis of childhood, and he apparently believes that calcareous infiltration of the regional lymph-nodes never plays a part in the secondary disease of later life. Our observations substantially corroborate his latter view, although there is an occasional exception. In a very few adult cases I have seen what appeared to be the development of a small calcareous deposit at the hilum where there were also pre-existing similar deposits. There are many more instances where a pre-existing calcific nodule shows in the roentgenogram only after a heavy perifocal haziness has cleared away, and unless caution is practiced it may be erroneously considered as having a

part in the current healing process. In our cases—even in those observed over periods of six or seven years—progressive healing by calcification in any part of the lung has seldom been demonstrated. For practical purposes, therefore, calcification participates to a slight extent or not at all in the repair of this type of disease, and it will be a profitless task for any roentgenologist to look through a series of pictures with the hope of discovering such tangible effects of calcium medication. There may be some other rational indication for such therapeusis, but it apparently cannot be founded on the supposition that the mineral salts usually densely infiltrate the caseous focus as they do in puerile tuberculosis.

Tuberculosis is a chronic relapsing disease. The assertion is trite, but for this very reason the phenomenon is baffling. Serial roentgenograms testify as eloquently as anything else to this fact and, a l too often, we see strikingly portrayed the thwarting of nature's devices to save the lung from destruction. At any stage, a picture of progressive repair may be transformed into one of unchecked devastation. The pathologist has shown that firm and relatively intact scar tissue may become thickly infiltrated with tubercles, and it is in this circumstance that we find the explanation for many roentgenographic mutations. Not uncommonly the dense, contracted shadow of fibrosis relaxes and melts down, perifocal inflammation again asserts itself, apparently obliterated cavities reopen and new areas of rarefaction appear to render the prognosis more gloomy. Again, the advance of the disease may be halted by reinforced anatomical repair, and another longer or shorter respite ensues. So we can graphically trace the alternating sway of opposing forces, meanwhile wondering all the more about the underlying cause of this most mystifying feature of the disease.

With the interchange of anatomical progression and retrogression goes a corresponding fluctuation of clinical symptoms. Were it possible to express serial roentgen-ray findings in the terms of a geometrical curve, we would find the undulations of the roentgen-ray curve closely paralleling those of the toxemic curve. And if it is ever possible to construct a dependable serological curve, it is certain that, from the three, valuable conclusions will be drawn.

No mention has been made of extrapulmonary changes. These are often mechanical and self-explanatory. One apparently reflex phenomenon that may be noted in passing is the unilateral inhibition of the diaphragm. This fixation commonly fluctuates with the intensity of the inflammatory reaction within the lung or pleura; when perifocal haziness is heavy, diaphragmatic inhibition is maximum; when clearing is observed, normal position is approached or entirely regained.

Pleural annular shadows are most interesting. At the Trudeau Sanatorium they were observed in 11.8 per cent of 423 cases; at the Loomis Sanatorium I have seen them in as many as 20 out of 100 consecutive cases. Formerly they were not distinguished from cavity, but today we feel reasonably certain that they are an entirely different thing. By some they are thought to be due to small localized pneumothoraces secondary to rupture of the visceral pleura, but for reasons outlined elsewhere* I have been led to the belief that the underlying lesion is a simple localized pleurisy with or without separation of the pleural layers; in the latter event a small effusion is often present. In many instances, especially if the shadow is situated in one of the interlobar fissures, it is impossible to state definitely whether the appearance is that of a cavity or something else. Serial roentgenograms often decide the question. When a sizable annular shadow disappears in the space of a few weeks, and there is no increased mottling or clouding, it certainly was not a cavity. Likewise, when the shadow rapidly enlarges without the rarefaction of surrounding confluent mottling, and without an increase in the patient's sputum, it is fairly safe to say that it is not a cavity. The rapid fluctuations in size are the most striking characteristics. Our recent investigation indicates that the shadows increase in size when the underlying pulmonary lesion is active, and decrease and disappear when such lesion becomes retrogressive. I shall not discuss the phenomenon at further length

* *Amer. Rev. Tuberc.*, Nov., 1921, v. 723.

except to express the hope that roentgenologists will look for these shadows and follow them to autopsy where their exact nature will finally be established. On first thought it may appear strange that postmortem studies have not already been sufficiently elaborate to decide the point; the explanation is that the structure will be entirely destroyed or overlooked in removing the lungs and tearing adhesions unless the pathologist makes a careful examination *in situ* of the area involved. The shadows appear most distinctly where the disease is not dense and extensive; such cases, of course, are not often seen at autopsy.

In this review of anatomical mutations no effort has been made to consider the atypical and the unusual. Our studies are by no means completed; in fact, it will require much work before all the possibilities of serial roentgenography of pulmonary tuberculosis can be appreciated. I have attempted to indicate some of these possibilities in the hope that the method will be more widely applied. Certainly a serial roentgenographic record portrays structural changes in the living subject much better than any other means at our disposal. It is hardly necessary to point out that a current record of any kind is of far more value in a disease like chronic tuberculosis than one or two isolated observations. The distinctive advantage of current stereoscopic roentgenographic data resides in the fact that it is much more accurate than the only other method we have for following detailed structural changes; I refer to physical signs. Physical examination, essential as it may be, cannot possibly convey certain very definite impressions that we get from the roentgenogram. For instance, in some cases there may be little or no change in the character or extent of dulness, altered breathing and râles, while serial pictures show progressive clearing and a slowly developing tracery of fibrosis. In such cases, symptomatic observation may be even more definitely informative than physical signs. This need not depreciate physical signs; it merely emphasizes one of their limitations and, by contrast, demonstrates in greater relief certain superiorities as well as certain limitations of the roentgen ray. Inferentially, this brings up one of my original points; namely, that the methods should be employed to supplement one another. The roentgenologist who would study tuberculosis can no more detach himself from the clinician than the latter can get along without the roentgen ray. Cooperative endeavor is the master word. Tuberculosis will constitute a simpler problem once we amass sequential and correlated data established by methods of dependability. Roentgenography of tuberculosis, within its limitations, is dependable.

THE EFFECTS OF THE X-RAYS AND RADIUM ON THE BLOOD AND GENERAL HEALTH OF RADIOLOGISTS*

BY GEORGE E. PFAHLER, M.D.

Professor of Radiology, Graduate School of Medicine, University of Pennsylvania

PHILADELPHIA, PENNSYLVANIA

THE report of 5 deaths from aplastic anemia, due directly or indirectly to the radiations of radium or *x*-rays, is of deep personal interest to every radiologist. Even though these deaths are not fully accepted as being due directly to the radiations, still it has seemed to me advisable that we, as American radiologists, should take account of our present status. If we are in such danger, it is clearly evident that we must take sufficient additional precautions to avoid these accidents. Even if, as a whole, we are sufficiently protected and sufficiently cautious, there may be individual workers who are taking unnecessary risks.

If we are not running any such grave risks, we must not add further to the unjust prejudice against us on the part of life insurance companies, which is apt to form as a result of these reports. Some companies actually refuse to issue insurance to those engaged in radiological practice, because of the accidental deaths which have occurred in those who were exposed excessively in the early days of roentgenology, when the dangers were unknown, and the means of protection undeveloped.

The insurance companies should realize that they have not actually lost money because of these deaths. The development of every powerful agent for good leads to the sacrifice of some lives, but the saving and prolongation of other lives compensate a hundredfold for these losses. Some pioneers in radiology sacrificed their lives in the development of this branch of medical science, but I am sure I can say truthfully that for every death more than a thousand lives have been saved, and many thousand prolonged, because of the benefits which have come from the aid given in diagnosis and treatment. I believe no one will dispute this. Then the insurance companies have gained in actual cash, because of the prolongation of premium paying, and the prolonged use of the money invested. Therefore, instead of their prejudice, there should be an everlasting debt of gratitude.

Preceding these 5 cases referred to above, the deaths of radiologists from excessive radiation have been due to the development of malignant disease secondary to the chronic irritation of the skin. This skin irritation has been practically eliminated, or at least the means and knowledge are at hand to give protection against such effects. Those entering the field of roentgenology or radiation therapy during recent years should be free from all such effects. For this second reason, present-day prejudice of insurance companies against radiologists is unjustified.

As the amount of radium used in medical practice increases, and as the *x*-rays are being made more powerful, we may be facing new dangers. It is better that we investigate now.

The deaths of 3 workers at the Radium Institute of London have been attributed to their occupation. The first death[1] occurred in December, 1916, in a worker who was seen by several eminent specialists, and whose death was ascribed by them to pernicious anemia. The second death occurred in January, 1920, in a nurse, and was due to infective endocarditis, but it is admitted that the radium had unquestionably affected her, though it was not from this alone that she died. The third death occurred in February, 1921, in a man, aged forty-seven, and was due to acute pneumonia. Each case is claimed to have been due to a definite disease apart from the effects of radium, but the Institute Committee consider it highly probable that the work of these persons weakened the power of resistance to the diseases from which they suffered.

* Read at the Twenty-Third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Cal., Sept. 12–16, 1922.

Larkin[2] reports a fourth case in which the disease was ascribed to the effects of the *x*-rays. A male, aged forty-three, had been working at radiography for fifteen to eighteen years. He was of excellent physique, and for eighteen months had been putting on weight; his general health had never been better. His complexion had always been sallow, a fact which unfortunately masked the onset of the fatal anemia. In October, 1920, a blood examination, casually made, showed Reds, 4,200,000; Whites, 7,200; Hb., 85 per cent; Diff. L., 38 per cent; P., 60; E., 1.7 per cent. This was three months before he complained of symptoms, and five months before death. In January the patient's color changed to a lemon yellowish tinge, and he complained of dyspnea and loss of appetite. He still kept on working at high pressure, and refused to consult any one. On Feb. 4, 1921, however, he gave in. His temperature at this time was 100.6°F. at night, pulse 90. He had backache. Blood pressure was 110. Blood count now was Reds, 2,700,000; Whites, 1,600; Hb. 54 per cent, L., 76 per cent; P., 20 per cent; E., 3 per cent. This showed a serious drop in both red and white corpuscles and a complete inversion of the ordinary percentage relation of lymphocytes to polymorphonuclears. No poikilocytosis, no nucleated reds, and no variation in the size of the red cells were to be seen. Urine showed nothing. He had a hemic murmur, but no evidence of endocarditis. Bacteriological examination of the blood on two separate occasions gave negative results. He grew progressively worse and died March 21, 1921.

I am referring to this case in a little more detail because the radium cases have received a little more publicity, and some roentgenologists assume that only radium workers need be concerned. In this case there seems to have been no other associated disease. Dr. Larkin remarks that this radiographer had recently changed over from soft to hard tubes for the greater part of the work, and he warns us that the protection that we used for soft tubes is insufficient for hard tubes.

Foveau de Courmelles[3] refers to a fifth case, Dr. Emilio Tiraboschi, radiologist for fourteen years at the large hospital in Bergamo, making use of hard tubes without precautions, who died in January 1914, "in a state of profound anemia. At autopsy upon his body considerable changes were found in the blood, advanced glandular atrophy, and the well-known lesions of extreme exhaustion."

After the deaths in the Radium Institute in London, Dr. J. C. Mottram was appointed to make a special investigation[5] of the effects of radium on the staff of the institute. For a year he made examinations of the blood of every worker, from the superintendent down to the hall porters. He found definite changes in the red and white corpuscles, due to exposure to radium. He showed that radium workers are subject to widely different amounts of irradiation according to the period of exposure. Laboratory workers who prepare and measure applicators containing emanation and radium, and clinical workers who attach screens to the applicators and subsequently apply them to patients, are especially exposed. Other workers, down to the servants of the institution, are subject to only small quantities of the gamma radiation which pervades the whole building. The polymorphonuclear and lymphocytic blood count of radium workers was found decidedly lower than that of normal persons. As a result, an extremely thorough protective system has been established.[4,5]

On Aug. 3, 1920, before the Pathological Society of Great Britain and Ireland, Mottram[6] made a report of the red-cell blood content of those handling radium for therapeutic purposes. He gathered material from outside the institution as well, and found that clinical and laboratory workers present, on the whole, a diminution in the number of red cells as compared with the unexposed workers. However, they fell within normal limits with five exceptions, three male and two female clinical workers. The three males (4.15, 4.2 and 4.3 millions per c.mm.) are a little below the lowest male found by Bing[7] (4.4 millions). The two females (3.3 and 3.4) were, however, very much below Bing's lowest female (4 millions). The color index was high.

Mottram then refers to three fatal cases, accompanied by anemia, which have

occurred among radium workers. Apparently two of these occurred in the Radium Institute, and are probably the same cases referred to above and reported by Pinch.[1] The third was a case occurring in France, (it may be the same as the case referred to by Foveau de Courmelles,[3]) or it may, possibly, be the sixth on record. "Case C., aged about fifty years, had worked with radium for ten years. Previous to this his blood presented some anomalies, notably a mast-cell leucocytosis. His illness was of short duration, and was diagnosed as aplastic pernicious anemia. No post-mortem examination was made.

"Reviewing these three cases, and taking into account the great rarity of aplastic pernicious anemia, it might reasonably be concluded that exposure to radium was the important etiological factor. When, however, the blood examinations of other workers is also taken into account, the above conclusion becomes hardly open to doubt. The anemia found was of exactly the same type, only less profound. Add to these facts the constant occurrence of a marked leukopenia, and a complete absence of signs of regeneration, and it is clear that the hematopoietic system of these workers is seriously damaged. The aplastic pernicious anemia found differs from the rare disease of young women in being accompanied by a leukopenia instead of a leucocytosis. In this respect it is similar to certain anemias produced by poisons, as for instance, trinitrotolnol."

A definite improvement in the blood picture was noted after the workers had been away from radium exposure for several months. Yet, it will be noted in the history of two of the fatal cases, that their symptoms developed after vacations of several months.

Experiments on animals[8] show that the bone-marrow is less affected by *x*-rays than are the lymphoid tissues. Warthin[9] found an inhibition of white cell productions and a preponderance of senile over young forms.

Regaud[10] says operators and attendants can protect themselves by forming the habit of: (1) Taking judicious advantage of the law of distance (especially through the use of special tongs in performing manipulations) and (2) interposing between the operator's body and any source of radiation leaden screens several cm. thick and impervious to penetrating rays. The few accidents that have occurred up to the present time have been the results of ignorance of the danger and lack of precautions.

Tuffier[11] collected information from various sources and found some complaints of cutaneous lesions, rarely menstrual disorders, azoospermia, and a reduction of polymorphonuclear elements and an increase of lymphocytes in the blood.

Portis,[12] in recording the result of blood studies made of a number of roentgen workers during a year, says, "There has not been a uniform blood picture. The majority, however, show a diminution of the total number of leucocytes which, in some cases, has been progressive. The lymphocytes were commonly relatively increased, and, at times, this was the most pronounced finding. A closer examination of the lymphocytes showed abnormal varieties described by some as unripe forms and by others as irritation forms. Myelocytes were found in three cases in small number. The red corpuscles and platelets were not affected, and the hemoglobin only slightly reduced.

Fortunately, the further investigations by Mottram[13] upon the effect of increased protection give us much encouragement. He says: "Increased protection has now been in operation for six months. As will be seen, this has resulted, with few exceptions, in a return of the blood conditions to normal." He gives a description of the methods of protection: "It is, however, not enough to provide protections; the workers must know how to take advantage of them. One has heard of a case of a nurse who was accustomed to carry radium each morning from one room to another. She suddenly developed a bad radium burn of the hand, which was accounted for by discovering that some days previously she had had a long conversation with a friend in the passage between the two rooms."

More recently Mottram[13] has collected 40 blood counts from healthy adults, 20 in radium workers and 18 in roentgen-ray

workers, showing the lymphocytes and polynuclear distribution to be abnormally low, particularly in the radium workers. Observations should be made on workers before they are subjected to exposure and then periodic blood examinations should be made. Under these conditions a fall, followed by a sustained low level, would indicate that insufficient protection was being provided. The red cells are not as sensitive to radiation as are the leucocytes, so they make a less delicate indicator. For this reason an anemia must be looked upon as a grave departure from the normal and will indicate a serious overexposure. Red cells are diminished in numbers in radium workers although the color index is high, probably indicative of interference with the production of red cells and polynuclears in the bone-marrow; and observations on the bone-marrow of rats exposed to gamma rays are confirmatory. The penetrating gamma rays of radium react and injure the bone-marrow, whereas the less penetrating roentgen rays exhibit their effects chiefly upon lymphocytes and lymphoid tissues which are not protected by a covering of bone.

EXPERIMENTAL WORK

A considerable amount of experimental work has been done in the study of the effects of radium and *x*-rays upon the blood, especially by Russ[14,15,16] and his co-workers. In 1919, they showed that the lymphocytes in the blood of the rat are extremely vulnerable to small doses of *x*-rays. In his recent paper[16] he states that the cells are more delicate indicators of *x*-rays than is an ordinary *x*-ray plate; and then refers to the experiment which he believed demonstrated it. A rat,the blood-count of which had been taken, was exposed to *x*-rays for $\frac{1}{40}$ of a second; 1 hour later a blood-count showed a reduction of 20 per cent in the number of lymphocytes. An *x*-ray plate was then placed in the position previously occupied by the rat and a similar exposure given. The plate, on development, showed no visible photographic action. A normal rat exposed for 12 seconds to *x*-rays, and examined 1 hour later, showed a reduction of about 50 per cent in the circulating lymphocytes; the time of exposure may be considerably increased or decreased without any appreciable change in this percentage. He then raises the question of the possibility of a group of sensitive lymphocytes which, when once destroyed, cannot be quickly replenished, and no further reduction occurs.

Taylor, Witherbee and Murphy[17] found that *x*-rays in large doses affect the lymphocytes before any of the other circulating cells. There is a sharp fall in the total number of circulating lymphocytes, which is complete forty-eight hours after treatment. Following the immediate decrease there is a primary rise, followed by another fall, which in turn is followed by a permanent rise of these cells to normal. Various animals were used in these experiments.

Levin[18] conducted experiments on the turtle and the normal frog, and found a marked reduction in the lymphocytes within twenty-four hours.

Leitch,[19] in a brilliant paper, makes a very timely criticism upon animal experiments and seems to have eliminated errors in his technique of handling the animals. He says: "We know that the numbers of lymphocytes in the blood vary within considerable limits from time to time, and even (a fact which is not generally appreciated) from hour to hour, but we can fix a maximum limit which they do not normally exceed. The compensating mechanism whereby this limit is kept has baffled explanation until quite recently. A few months ago, Bunting and Huston[20] showed that there is a continual loss of lymphocytes through the intestines. In sections they can be seen traversing the bowel epithelium, and they can be found in large numbers in the fluid contents. We may suppose that they discharge some digestive function in the lumen of the bowel, and that their numbers correspond with the local demands; indeed, it is probable that exceptional local stimuli induce unusually large emigrations of the lymphocytes from the blood-vessels into the contents of the gut. There are only two ways in which Russ's reduction can be explained; either the normal addition of new lymphocytes from the lymphatic channels is inhibited, or the loss through the intestines is increased. The latter seems to me to be the more probable occurrence. We need not invoke

the supposititious differences of lymphocytes to explain the decrease.

"I may be allowed to say that the evidence in favor of a defence being set up by the lymphocytes in cancer is anything but conclusive; it is very questionable. Secondly, it is a risky thing to argue from one animal to another of a different species; the human being does not necessarily react in the same way as a rat. In order to settle this point we examined the blood of a few patients taken at random. The material for complete blood counts was taken immediately before, and again from one and a half to three and a half hours after the end of the *x*-ray sitting.

"It will be seen from the table that in the first three cases there was no diminution in the number of the lymphocytes; they had actually increased in the interval. The increase in the first two cases is of no moment; the differences in the figures are such as one would expect from random samplings; they are quite within the narrowest limits of experimental error. The blood-corpuscles are not so uniformly distributed that one drop contains exactly the same number as another drop; even if, by chance, we got the same numbers of white corpuscles in two drops we could not expect the same proportions between the different varieties of leucocytes; and, in actual practice, no two people would arrive exactly at the same figures if they examined the same preparations. We reckon on a certain amount of latitude. The third case shows a still greater increase in the lymphocytes, and the increase is beyond what we should usually allow for errors of random sampling. It is, however, quite a normal physiological variation, recognized as such by pathologists. The fourth case shows a diminution of lymphocytes, in spite of a total leucocytic increase, of no great degree, and is still a normal variation. In the last case it will be seen that, though the total number of leucocytes has increased, the lymphocytes have fallen by 26 per cent. This case might be cited as supporting Russ's thesis. Still, one swallow does not make a summer. It may quite well be a normal variation, but the following particulars are not without significance. The patient was a woman of fifty who had had her breast removed four years before for cancer. She had no recurrence of the disease and had merely come to the hospital to report progress. She consented, after much persuasion, to allow me to examine her blood, and to undergo a few minutes' exposure to *x*-rays. So nervous was she that it required a nurse to hold her hand and another to hold her head while the drop or two of blood was being taken, and when she returned two hours after the *x*-ray application she was still trembling. If we dismiss the explanation that the decrease in lymphocytes in this instance was a normal variation, we cannot overlook the only other factor present in her case, and absent in the others, namely, fright. Everyone knows how fright or nervous excitement affects the intestinal apparatus, and it is very probable that under such stimuli the normal loss of lymphocytes by the intestines is correspondingly exaggerated. These few experiments are sufficient to show that Russ's conclusions, arrived at from experiments on rats, are not applicable to human beings." Note the following experiments on rats:

Treatment	Leucocytes			Lymphocytes		
	Before	*After*	*Difference*	*Before*	*After*	*Difference*
1. Lead screen interposed	14,800	9,800	−34%	7,962	4,860	−39%
2. *X*-ray tube cut out	19,900	14,900	−25%	15,840	11,533	−28%
3. *X*-rays, 4 minutes	13,300	5,100	−62%	10,640	3,315	−69%
4. *X*-ray tube cut out	14,200	13,800	− 3%	8,350	3,616	−57%
5. Docile rat, tube cut out	12,500	13,000	+ 4%	10,325	8,736	−15%
6. Nervous rat, *x*-rays, 2 minutes	22,000	9,500	−57%	16,544	6,593	−64%
7. Same rat as No. 5, *x*-rays, 2 minutes	20,400	13,000	−33%	17,748	10,816	−39%
8. Same rat as No. 6	8,800	9,000	+ 4%	7,286	3,021	−59%

BLOOD STUDIES OF AMERICAN RADIOLOGISTS

In November, 1921, at one of the regular meetings of the Philadelphia Roentgen Society, I proposed that we make a study of our blood. I was then appointed to make these investigations. I decided later to enlarge this plan and solicit the cooperation, if possible, of all radiological workers in America. A blank was prepared, with the cooperation of Dr. John Kolmer, Professor of Pathology, making the following queries:

CLINICAL RECORD FOR BLOOD STUDIES OF RADIOLOGISTS

Name. Age { Physician, Nurse, Technician
Address. { Stenographer, General Assistant
Name of laboratory.
Began work.

	Hours Each Day	Days per Week	Years
Amount of work			
Roentgentherapy			
Roentgenography			
Roentgenoscopy			

Amount of radium handled.
Do you prepare the specimens? How?
Do you apply the radium? How?
Describe your protection against the roentgen rays.
Describe your protection against radium.
What was your occupation previously?
Describe your general health before any exposure to rays.
Describe your general health or any present symptoms.
Mention any causes of present symptoms that occur to you.
Record blood pressure. S. D. PP.
Record any previous blood pressure tests.
Carry a dental film in your pocket for two weeks, marked with a lead number, and mail to me promptly in a tin box, without developing.
Record here the results of any blood examinations previously made.
Please have a blood examination made as follows at least two hours after previous meal.

	Date	Date	Date	Date
Total erythrocytes				
Total leucocytes				
Hemoglobin				
Differential leucocyte count				
Small lymphocytes				
Large lymphocytes				
Transitionals				
Polymorphonuclear				
Eosinophiles				
Basophiles				
Abnormal erythrocytes				
Abnormal leucocytes				
Blood clotting time				

Examined by
Remarks.

One thousand of these blanks were distributed in December, and by request several hundred more were sent out later. Yet only 338 were returned. Probably the most valuable contribution is that made by the medical director of one of our leading Radium Producing Companies. While he requests that his name be withheld, I take the liberty of quoting his "General Summary of Health Conditions in Radium Workers:"

"Since the establishment of the laboratories that have produced 85 gm. of radium (estimated to be upwards of 60 per cent of all the radium ever refined) there have been no deaths among the laboratory workers. One of the workers, with a continuous service of ten years, had lobar pneumonia in 1919 with a rapid and complete recovery. Another, also with ten years' continuous service, had a general infection (never positively diagnosed) with complete recovery. Five members of the staff, who have had constantly to handle radium tubes and needles, are suffering from radium effects on the thumb, index and middle fingers of both hands, produced in the very early history of the laboratory. Since the establishment of regulations that radium must be handled with instruments, this local condition has not progressed in any one of the cases.

"The general health of the laboratory workers is, I believe, above the average. Absence from duty on account of illness is very infrequent. During the 1918 epidemic of influenza, the entire staff escaped almost entirely, there being only one case.

"The general exposure at any one time has amounted to from 200 to 1,000 mgm. of radium in process of crystallization (emanation exposure), and from 100 to 2,000 mgm. of the finished product (gamma ray exposure). Members of the staff, represented in charts numbered 1, 2, 3, 4 and 5 have received the greatest amount of gamma radiation.

"The average blood count for members of the staff having had the greatest amount of exposure for a longer period than five years, is as follows:

R.B.C.		W.B.C.	Poly.
5,027,500		5,296	63.6 per cent
S. L.	L.L.	Trans.	Hemo.
12.6	22.3	2.5	94 per cent

Since this tabulation has been recorded, an additional count has been made which in no way differs from the individual counts recorded and tabulated.

"In addition to the above, one of the officers, not directly exposed to radium in the laboratories, has received during the

past eight years, 90,450 mgm. hours of gamma ray exposure to a pathological lesion. Treatment consists in the use of from 50 to 200 mgm. of radium used either directly on or buried in the growth. This officer is at the present time in good health, and presents the following blood count:

R.B.C.	W.B.C.	Hemo.
4,250,000	6,200	90 per cent

The case is quoted as being, perhaps, the largest radium dose on record."

This report was based upon repeated blood studies which had been made independently during a year, and the study of the individual charts is most interesting. No. 1 and No. 2 had been exposed for ten years, had damaged fingers, and had been exposed to about 85 gm. of radium, yet the blood studies made four times during 1921 showed a normal condition. The lymphocytes were at the low normal level. No. 3, which had nearly the same amount of exposure, showed a variable condition, but in March, July and September there was a moderate leukopenia, and a distinct relative lymphocytosis.

Male—Age 35 years—Married—No children.
Continuous Service—10 years (absent during war period).
Amount Handled—70 gm.
Special Duties—Gamma ray measuring.
Visible Effects—None.
General Health—Very good. Never been ill.

Date	3/28/21	5/20/21	7/27/21	9/30/21	11/29/21
R.B.C.	4,980,000	5,080,000	4,810,000	5,730,000	5,790,000
W.B.C.	3,800	5,000	5,050	4,200	5,800
Poly	48%	68%	44%	54%	64%
S.L.	10	.....	26	16	22
L.L.	40	32	28	24	12
Trans	.....	.....	1	4	2
Baso	2	.....	1	2	.....
Eosin	.....	.....	.....	.....	.....
Hemo	.....	.....	.....	97%	85%

No. 4 showed a constant leukopenia, and a relative lymphocytosis. No. 5 was normal yet had been in service eight years, working at gamma ray measuring and tracing lost radium, and suffered with effect on fingers, (not progressive since radium is handled with instruments), yet the blood remained normal. Nos. 6 and 7 remained normal. No. 8 showed a relative decrease in polynuclears, and an increase in lymphocytes.

Male—Age 41—Single.
Continuous Service—1 year.
Special Duties—Emanation measuring (samples).
Amount Handled—Cannot estimate.
Visible Effects—None.
General Health—Good.

Date	3/28/21	4/25/21	7/27/21	9/30/21	11/29/21
R.B.C.	4,980,000	4,380,000	4,390,000	4,560,000	4,610,000
W.B.C.	9,200	5,650	6,430	7,000	4,450
Poly	40%	32%	50%	40%	.....
S.L.	8	16	6	18	.....
L.L.	52	50	42	40	.....
Trans	.....	2	2	.....	.....
Baso	.....	.....	.....	2	.....
Eosin	.....	.....	.....	.....	.....
Hemo	.....	.....	.....	90%	82%

No. 14 and 17 showed similar conditions. No. 17 was a stenographer and received only short exposures to large amounts of radium. No. 18 showed a marked leukopenia, and a relative lymphocytosis, and yet was only the porter, handled no radium, and his general health was good.

Male—Age 29—Married—4 children prior to radium work.
Continuous Service—6 months.
Special Duties—Porter of laboratories.
Amount Handled—None.
Visible Effect—None.
General Health—Good.

R.B.C.	W.B.C.	Poly.	S.L.		
6,210,000	3,450	34	14		
L.L.	Trans.	Baso.	Myelo.	Eosin.	Hemo.
36	2	2	—	12	92%

Unfortunately none of these reports were accompanied by the dental films carried for two weeks.

DENTAL FILM VALUES

In order to form some idea of the relative amount of exposure that each worker got, I requested that each carry a dental film for two weeks. To get gradation values, I took the time necessary to produce an erythema dose, which with one of my machines requires 4 minutes (240 seconds) at 8 inches with a 9-inch spark gap and 5 ma. through 2 mm. Al. filter. At 80 inches' distance, this time becomes 2,400 seconds, according to the law of inverse squares. At this distance, exposure of ten of the standard (Eastman) dental films from 10 up to 100 seconds will show ten gradations from the faintest shadow to the darkest shade possible. Each of these shades will then measure from $\frac{1}{2.400}$ to $\frac{10}{2.400}$ of an erythema dose. In my own institute, of the 10 workers only 2 showed any fog, and these 2 who handled the radium and *x*-rays most, clinically, received in two weeks about $\frac{1}{2.400}$ of an erythema dose.

The majority of the films sent in showed no more, but many were entirely black; and since the film will only record a certain maximum shade of blackness, these people

are probably dangerously exposed. I would suggest that any one whose film, carried for two weeks, shows definite blackening, should increase the protection. This makes a simple practical test, which will give warning long before changes in the blood can be noted.

Among the other blanks returned were those of 175 physicians, 55 nurses, 62 technicians, 25 stenographers, and 16 general assistants. The stenographers were all normal, or at least had no symptoms or blood changes to suggest radiation effect. Therefore, the general radiation effect in our American laboratories can be ignored.

I found that the nurses, technicians, and general assistants all did more or less radiological work, and can therefore be classed together (159). Of this group there were only 10 which showed any abnormal symptoms, or blood change, or excessive exposure on the dental films. One of these showed 53 per cent lymphocytes, 38 per cent polymorphonuclears, and about 6,000 total leucocytes.

One of the correspondents remarks: "I am very well generally, much better in many ways than when I began *x*-ray work; but most of the time, after I leave the work for the day, I find myself completely exhausted, and it requires about nine hours' sleep to put me in good condition again. A peculiar thing about this feeling of exhaustion is, I do not notice it while around the *x*-rays. (She is supposed to have had Bright's disease preceding *x*-ray work.) She worked five and one-half days, five hours, at roentgenotherapy, for five and one-half years. Her blood was normal. Her film showed about $\frac{5}{24,000}$ of an erythema dose. One nurse noticed menstrual irregularity. Several showed an excess of exposure on the dental films.

The physicians showed most change, as might be expected. They do the fluoroscopic work, and most of the radium and roentgenotherapy. In general, they have been doing radiation work over a longer period and working more intensely. Those who work with radium or with the high voltage *x*-ray machines, showed an excess exposure on the dental films. I would therefore urge that these workers increase their protection until they can carry a dental film (face outward) for two weeks with little or no fogging.

The blood studies, if reduced to averages, would undoubtedly come entirely within the normal limits. In general, there is a tendency to a reduction in leucocytes, and a relative increase in lymphocytes, with a marked increase in eosinophiles, in a few cases. In most instances, these changes are only slightly beyond the normal limits, but when taken as a whole, and when compared with similar observations made by other authors, even though on a smaller scale, they are probably significant of excessive radiation and should be interpreted as danger signals.

The five worst blood records sent to me were as follows:

Total erythrocytes	4,900,000	5,080,000	5,140,000	5,210,000	4,600,000
Total leucocytes	5,900	4,400	8,100	7,200	6,600
Hemoglobin	95%	80%	100%	94	103
Differential leucocyte count:					
Small lymphocytes	31	42	42%	39	45
Large lymphocytes	14	7	1	8	.....
Transitionals	5	1	1	0	2.5
Polymorphonuclear	42	48	52.5	52	49
Eosinophiles	8	2	3	0	2
Basophiles	.....	.....	5	1	1

All these have occurred in physicians who have been at the work only a comparatively short time. Four of the five had black dental films. The fifth had only a faint fog on his dental film. These blood changes may be caused by some other conditions than radiation, but if due to radiation, then we must conclude that some of the younger men are not giving as much attention to protection as are the older workers. It is indeed surprising to find the blood of the older radiologists in such good condition.

The Blood-Clotting Time. Accepting three to five minutes as the normal, there

were only twelve reports of abnormal clotting time. These were respectively, 10, 7, 7, 9, 14½, 7½, 9½, 10, 7, 5, 7, 7, or a delayed clotting time in 3½ per cent. There was no abnormally rapid clotting reported. The one who had a nine minute clotting time had an eosinophilia of 12 per cent, for which he could give no cause. In other respects his general health and his blood were normal. The one who had a clotting time of fourteen and one-half minutes, had a systolic blood pressure 11 points below normal, but in all other respects he seemed to be normal.

Blood-Pressure. Accepting 120 mm. as normal for the age of twenty years, and adding 1 mm. for each two years above twenty as normal, there has been a general decrease in the systolic blood pressure. This has been the most constant abnormality found in these studies. The reduction varied from 5 to 38 points. In general there has been a reduction in systolic pressure of 10 to 15 points below normal. In only one marked case was there associated abnormal blood. In this one there was a 44 per cent lymphocytosis, and a 50 per cent polynuclear count, while the total leucocytes were 8,120. The low blood-pressure is too common to be ignored, but I believe that it is not caused by the radiation, because there are no other radiation effects corresponding, and it does not bear any relation to the amount of exposure, or the duration of service. It is most likely caused by the high tension electric effects.

General Symptoms. Only 11 out of 338 report any general symptoms which they attribute to, or which seem to be associated with, the occupation. This, it seems to me, is a fair percentage of health, and should not lead a diagnostician to attach great importance to the occupation as an etiological factor in general symptoms.

Sinusitis is reported by two. One simply says that the ozone from treatments irritates. The second reports "a steadily advancing pansinusitis (pyogenic) and a steadily decreasing resistance, sixteen carbuncles in 1920, thirteen abscesses in 1921, with loss of 'pep.' From a health viewpoint, I was considered A No. 1, until 1916—three years after entering *x*-ray work." Since then he has had several sinus operations and has quit *x*-ray work. He is recovering. It would seem unwise to attach much importance to the radiation in this case, since similar cases are not uncommon in people who are in no way exposed to the rays.

One physician reports a troublesome pruritis. Another reports duodenal ulcer, and says he knows of six radiologists who have duodenal ulcer.

Several report fatigue at the end of the day, and desire for a long night's rest. From my own experience and observance of other radiologists, all of whom work long hours and with great intensity, I am led to believe that a similar amount of work in any other line would probably cause similar fatigue. Though two or three seem to associate the fatigue with much roentgenotherapy, one associates it with much fluoroscopy, and lack of fresh air.

One radiologist reports as follows: "Four years ago, when commonly handling 500 mg. of radium, with lack of precautions, such as standing three to four hours daily near radium, unprotected, I found myself running an extremely low systolic B.P., 100 to 105. Three months later I developed what was diagnosed as degenerative changes in the heart wall. With this there came rapidly structural changes in the liver, phlebitis of severe type affecting both lower extremities. After treatment for six months I returned to guarded radium application, with complete recovery from all symptoms, including the myocardial. Blood: R. 5,100,000; W. 8,700; H. 85."

CONCLUSIONS

1. Undue exposure to the *x*-rays or radium is associated at times with a moderate leukopenia, a relative lymphocytosis, a relative polycynthemia, and occasionally an eosinophilia.

2. A low blood-pressure is quite common in radiological workers, which does not seem to be associated with any other definite symptoms.

3. The asthenia, sometimes noted, can probably be accounted for by strenuous work, caused by the great interest and also by the desire to meet the heavy "overhead" charges which must be carried by the radiologist. These symptoms are also

probably caused by close confinement, lack of fresh air, and lack of recreation.

4. The skin changes found in the earlier workers are not increasing, and are being avoided entirely by the younger ones, because of the increased knowledge and increased protection.

5. Complete protection can undoubtedly be obtained. It requires not only the means, but continual caution on the part of the individual.

6. Increased protection is needed by those who are working with the gamma rays, or with the higher voltage *x*-rays.

7. A dental film carried in the pocket for two weeks, will give a quick index of excessive exposure. If definitely fogged or blackened, protection should be increased.

8. Shortening the hours of work and increasing the amount of fresh air and recreation will probably remove symptoms, and prevent future trouble.

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CARCINOMA OF THE UTERUS WITH PREGNANCY INTERVENING TREATED SUCCESSFULLY BY RADIUM FOLLOWED BY DELIVERY OF A NORMAL CHILD*

BY C. EVERETT FIELD, M.D.

Radium Institute of New York

NEW YORK CITY

FEMALE, aged thirty-nine years, married. American born, of Irish and English parents. Mother luetic, died at seventy-four years of age of a chronic myocarditis. Father a sailor, died as a result of an accident at sea. Has one brother, well; no sisters. Has had diseases of childhood. Was married at nineteen years of age.

History of Pregnancies. First, at twenty, normal, and normal child now living. Second, at twenty-two, resulted in miscarriage. Third, at about thirty. In seventh month developed growth of inferior maxilla, which broke down leaving large scar. Child born blind, and died at age of two weeks of congenital disease. Fourth, normal, child normal, died at six months of marasmus. Fifth, resulted in stillbirth at fifth month. Pathological examination of fetus and placenta showed evidence of leus. Stillbirth occurred in May, 1914. Sixth: In view of the previous stillbirth, patient was advised a Wassermann test, but refused to have it made. She was therefore put on mixed treatment, and had normal pregnancy and childbirth. The child later developed marasmus, but was put on specific treatment, and is now normal. Was born May 15, 1917. As a result of this labor, there was considerable laceration with a great deal of induration. Patient was ordered to hospital for repair or amputation of cervix, but refused treatment. For a full year patient complained of a foul vaginal discharge.

Seventh pregnancy, normal to fourth month, when the present illness was ushered in on December 24, 1918, with a marked hemorrhage from vagina. The patient was found in a semi-comatose, pulseless, and serious condition. She had not menstruated in four months. Vaginal examination showed that the blood was not coming from within the uterus. The cervix was not dilated, but the fundus was the size of a four months' uterus. The cervix showed a cauliflower growth of the size of a large egg, and blood was coming from the edge of the cervix. Bleeding subsided and the patient was removed to a hospital, where a diagnosis of incomplete abortion was made, with the placenta in the cervix. The diagnosis was later changed to cancer of the cervix, and this was confirmed by two consultants. Cauterization was advised, but the patient refused it. She remained in the hospital about two weeks and went home. There was a continuation of the bleeding and she was later removed to a private hospital. After consultation, it was decided that surgical intervention would result in the death of both mother and child, and radium was resorted to.

The case was referred on March 1, 1919, by Dr. Lee Wilson Thomas of Brooklyn, to the Radium Institute of New York, under the author's service. Examination at this time showed the cervix to be the center of a cauliflower growth of about 7 cm. diameter, with an extension upward along the posterior wall of the uterus and along the anterior surface of the rectum. Pressure symptoms on the bladder were prominent, but there were no signs of malignant involvement. The patient was in a state of extreme exhaustion. The blood count showed red corpuscles 3,200,000; whites, 6,000.

Treatment. Radium application, March 3, 1919, consisted of 100 mgm. radium element introduced within the cervix (screen 1 mm. gold and brass; 0.5 mm. rubber) for a period of eight hours; crossfiring from a sacral pad containing 300 mgm., screened with 1½ cm. felt, 1½ mm. rubber and ½

* Read at the Seventh Annual Meeting of THE AMERICAN RADIUM SOCIETY, St. Louis, Mo., May 22–23, 1922.

mm. metal, for a period of sixteen hours. The second radium treatment, instituted March 11th, consisted of a postcervical bomb of 140 mgm., screened with 1½ mm. brass and 1½ mm. hard rubber for eight hours. The third radiation, March 26, 1922, consisted of 100 mgm. radium element, standard screen applied within the cervix for six hours. The total radiation utilized consisted of 7,320 mgm. hours.

The clinical observation showed a control of all hemorrhage ten days following the first radiation, together with a marked general improvement in the patient's physical condition.

On April 12th, the patient reported for examination, about five weeks after the institution of the radium treatment. The malignant mass involving the cervix was practically gone and but a trace of the vaginal wall lesion was to be found.

Although all arrangements had been made to deliver the woman by an abdominal operation, the case proceeded uneventfully until April 26th, when a normal labor attended with but little pain, brought a four-pound girl baby. There was no serious hemorrhage or laceration. The patient returned home after two weeks and resumed her housework.

On September 14, 1919, she was returned to the Institute for treatment of a recurrence in the cervix. One treatment was given, consisting of 100 mgm. in the cervix for eight hours, and 125 mgm. packed against the cervix posteriorly for the same period. The patient apparently improved and kept at her duties until April, 1920, when she developed a metastasis in the liver and died June 17, 1920.

The child is now three years old, of a healthy and beautiful type.

THE TREATMENT OF BENIGN CONDITIONS OF THE PELVIS WITH RADIUM*

BY LEDA J. STACY, M.D.

Section on Medicine, Mayo Clinic

ROCHESTER, MINNESOTA

THE efficacy of radium in the treatment of operable carcinoma and myoma of the uterus is still a moot question. In reviewing the literature of the last two years on the treatment of benign tumors of the uterus, however, it is evident that radium is becoming more universally recognized as "an adjunct of surgery and not its competitor." The majority of writers recognize the fact that in certain groups of cases surgery is the more conservative treatment; for example, myomectomy in a woman under thirty-five with multiple fibromyomas; and even hysterectomy if necessary, as the function of the ovaries may be less disturbed by this than by repeated large doses of radium given to reduce the size of a large tumor. Again, in the young woman without demonstrable tumor of the uterus and with menorrhagia which has not been controlled by medical treatment or curettement, abdominal hysterotomy is indicated rather than radium. In such cases, a small intra-uterine fibromyoma or a polyp which has been missed by the curettement is often found, and its removal relieves the symptoms. Pregnancy may occur following the use of radium, but only in a small percentage of cases. In our series of 1,013 patients treated with radium in the Mayo Clinic since 1915, four women have each had a living child, three gave birth to dead fetuses, one had two miscarriages, and one was pregnant at the time of the report. In a series of 741 myomectomies, thirty-three women later raised one child and eleven raised two or more children.[7] Sterility following the use of radium may be due to two factors; the destruction of the graafian follicle by the

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radium rays, and connective tissue infiltration of the endometrium which interferes with implantation of the ovum.

FIBROMYOMAS

Most writers consider that tumors larger than a four months' pregnancy are best treated by surgery unless it is definitely contraindicated. A history of pelvic infection within three to four years, evidence of pelvic infection at the time of examination, and ovarian tumors are definite contraindications to the use of radium. Submucous fibromyomas presenting at the cervix and rapidly growing tumors of the uterus should be removed. The fact that carcinoma of the fundus may develop after radium application should be carefully considered in the subsequent course of these patients. Carcinoma has occurred in three of the series of 1,013 patients. I reported one case in 1920, and the other two have occurred since then. One was in a woman aged fifty-five years who came to the Clinic in March, 1920, complaining of irregular menstruation. She had had a Watkins-Wertheim's operation for prolapsus six and one-half years before. Because of the difficulty of performing hysterectomy fo lowing the interposition operation, it was thought advisable to use radium. One intra-uterine irradiation of 600 mgm. hours was given. Bleeding did not occur for six months, and then there was a return of the occasional bloody discharge without odor. In January, 1921, another treatment of 700 mgm. hours was given; this did not stop the bleeding. Five months later, another 700 mgm. hours of radium and roentgen-ray treatments over the abdomen were given. The patient returned in January, 1922, and said that she had had a great deal of lower abdominal pain, especially when she was on her feet, and bloody discharge occasionally. The uterus was large, firm and tender. Another series of deep roentgen-ray treatments was given, which did not entirely control the bloody discharge, and a month later hysterectomy was advised. At operation an extensive adenocarcinoma of the fundus was found. The third patient came to the Clinic in 1919 with a diagnosis of fibromyoma of the uterus. Her menstrual periods were irregular, but there was no unusual leukorrhea or metrorrhagia. The uterus was large and fibrous. The systolic blood pressure was 186, and diastolic, 120. One intra-uterine treatment of 500 mgm. hours of radium was given. The patient had two normal menstrual periods following this and then no discharge for two years when there was once a slight flow for a few hours, and a slight leukorrhea which she had "had always." Six months later, the leukorrhea became watery and occasionally bloody, and there was considerable low abdominal pain. This had continued for three weeks when she returned for examination in November, 1921. The uterus was then found to be about twice normal size, firm, and freely movable. A diagnosis of probable carcinoma of the fundus was made and abdominal hysterectomy advised. At operation, an extensive carcinoma of the fundus which had extended to the pelvic peritoneum was found. The malignancy was much more extensive than the history of the case indicated.

Radium may not have been an etiological factor in these three cases, but it should be taken into consideration in all cases of recurrence of bleeding after a period of one year or more of amenorrhea following radium treatment.

Delbert quotes Mornard as reporting 3 cases of particularly rapidly growing cancer developing after radium treatment, although he says that there is no basis for supposing that the radiotherapy was the cause of the cancer. He emphasizes the need, however, of careful diagnosis before radium treatment is instituted. Jacobs also reports instances of malignancy following the use of radium.

If the history is suggestive of malignancy, hysterectomy is advisable although the findings on curettement are negative.

Results from radium therapy given during the last two years at the Mayo Clinic are given in Table I. Between October 1, 1919 and July 1, 1921, 413 patients have been given intra-uterine radium treatments for menorrhagia and benign tumors of the uterus. Of the 305 who were aged thirty-eight years or more, 198 (96.59 per cent of those heard from) had

had cessation or lessening of profuse flow. Menstruation had ceased in 151 (64.25 per cent). Of the 108 who were less than thirty-eight years, 62 (91.17 per cent) had had cessation or lessening of profuse flow. Menstruation had ceased after treatment in 9 (13.23 per cent). Four patients had hysterectomy following radium treatment; one, eight months after treatment because of dysmenorrhea which had increased after the radium treatment; the second, sixteen months after treatment, with 363 mgm. hours, because of continued profuse flow and increase in size of the uterus. The third was operated on elsewhere thirteen months after treatment; the fourth two months after treatment, because of persistent menorrhagia.

ADENOMYOMAS

The location of adenomyomas or their adhesions to the surrounding structures are often such that removal may not only be difficult but may necessitate extensive dissection. This is particularly true if the tumor is in the rectovaginal septum or at the juncture of the fundus and the cervix. In this group of cases, radium has been of distinct value. Twenty-two cases of adenomyoma of the uterus have been treated at the Clinic since 1915. Pathologic diagnosis was made in 14. The youngest patient in the series was aged twenty-five years, the oldest fifty-two. Eleven patients have been heard from or recently re-examined. The tumors of 6 had definitely reduced in size; the tumor of one had disappeared. In 2 instances the tumor was not mentioned; two patients are dead.

Seven of the tumors were located in the rectovaginal septum; 5 in the posterior vaginal fornix, one of which was apparently a broad ligament tumor adherent to the posterior vaginal mucous membrane; one was at the juncture of the fundus and cervix; 3 apparently were in the broad ligament; 2 were single adenomyomas of the uterus projecting through the cervical canal and were removed by vaginal myomectomy; one radium treatment was applied after operation in each case. There was one case of single pedunculated adenomyoma growing from the cervical canal. Two patients of this series are dead. One presents an interesting history. She was first examined at the Clinic in 1907. At that time, there was a hard nodular growth in the right posterior vaginal wall which was diagnosed clinically as cancer of the vagina. She was not operated on at that time, and returned to the Clinic nine months later, but apparently there had been no change in the tumor. She was examined again in February, 1920, when she was having attacks of hematuria without pain. The original tumor had apparently not increased in size, but there were several small nodules scattered over the wall of the vagina. She was given 2,386 mgm. hours of irradiation by vagina and rectum. Examination a year later disclosed slight induration extending from the introitus to the vault of the vagina on the right side. The growth projected into the rectum, but there was no ulceration of the rectal mucous membrane. The patient's general health was good, and treatment was not given at this time. She died one year later, after an illness of two months, and it is a question whether death was due to the original trouble. One patient on whom myomectomy was performed had an adenomyoma on the posterior wall of the uterus, adherent to the sigmoid and culdesac, and apparently not encapsulated. A specimen was removed for diagnosis, and during convalescence the patient was given one intra-uterine and one vaginal treatment with radium. This patient died subsequently, but cause and time of death are unknown.

Two patients, each of whom had had one intra-uterine treatment with radium for menorrhagia, were operated on five and eight months later respectively; one, because of continued bleeding and the other, because of a profuse foul vaginal discharge suggesting malignancy of the fundus, although bleeding had ceased after radium treatment. At hysterectomy, diffuse adenomyoma of the uterus was found in each.

Another patient had a large adenomyoma, about 13 cm. in diameter, in a ventrofixed uterus adherent to the abdominal wall. An exploratory incision showed the tumor to be adherent to all surrounding tissues; total removal was not attempted. Radium was applied over the abdomen

and into the uterus. A month later, examination revealed that the tumor was reduced to a small ridge about 2 cm. in diameter.

The technique employed varies according to the location and size of the tumor; the emanation needles are inserted into the growth, if it is located in the recto-vaginal septum, or the radium is used in the vaginal pack and rectal applicator. If the growth is high in the posterior fornix at the cervicofundal juncture, the vaginal pack is used combined with radium inserted into the cervical canal. Between 1,600 and 2,400 mgm. hours has been the average total dosage, given in two or three doses, using 50 mgm. at each dose for fourteen hours in the vagina and 50 mgm. for two hours in the rectum in two doses, although as much as 6,000 mgm. hours has been used in a case of a large fixed tumor in the posterior fornix adherent to the vaginal mucous membrane and to the rectum.

TABLE I

RESULTS OF INTRA-UTERINE RADIUM THERAPY FOR NONMALIGNANT CONDITIONS

October 1, 1919, to July 1, 1921

	Number	Per Cent
Patients treated	413	
Single	29	
Married	384	
Heard from	309	
Patients aged thirty-eight years or more (Average age 46.08 years)	305	
Patients heard from	235	77.0 of 305
Fibrous uterus	78	
Definite fibromyomas	110	
Questionable fibromyomas or fibrous uterus	47	
Profuse flow before treatment	205	87.23 of 235
Cessation or lessening of profuse flow after treatment	198	96.59 of 205
No cessation or lessening of profuse flow after treatment	7	3.4 of 205
(Average dose to cause cessation of profuse flow 734.55 mg. hours)		
Two treatments	12	
Three treatments at long intervals	1	
Cessation of menstruation	151	64.25 of 235
Hysterectomy performed later in an average of 8.75 months after radium treatment	8	3.4 of 235
Patients less than thirty-eight years of age (Average age 32 years)	108	
Patients heard from	74	
Definite fibromyomas	31	
Fibrous uterus	32	
Questionable fibromyomas or fibrous uterus	11	
Profuse flow before treatment	68	91.89 of 74
Cessation or lessening of profuse flow after treatment	62	91.17 of 68
No cessation or lessening of profuse flow after treatment	6	8.8 of 68
Cessation of menstruation	9	13.23 of 68
(Average dose to cause cessation of menstruation 397.66 mg. hours)		
Hysterectomies after radium treatment	4	
Eight months after treatment because of dysmenorrhea which had increased after radium treatment	1	
Sixteen months after treatment with 363 mgm. hours irradiation because of continued profuse flow and increase in the size of the uterus	1	
Operated on elsewhere thirteen months after treatment	1	
Operated on elsewhere two months after treatment with 340 mgm. hours irradiation because of continued profuse flow	1	

ENDOCERVICITIS, PRURITUS, AND KRAUROSIS

The series of cases at the Clinic of endocervicitis treated with radium has been too small to admit of a definite conclusion regarding its efficacy, although a cervical discharge, persisting after abdominal hysterectomy, has ceased after one or two treatments of 700 mgm. hours of radium. Curtis, in 1920, reported satisfactory results without resulting amenorrhea or atresia of the cervix in his series.

In our experience, pruritus vulvae has been more satisfactorily treated by roentgen rays than by radium, although radium has given relief in many instances. In cases of kraurosis with pruritus, short treatments with unprotected radium have given a great deal of relief by controlling the pruritus, but apparently do not influence the kraurosis, although, according to theory, radium should stimulate the superficial circulation and overcome the atrophy.

CONCLUSIONS

1. Radium, then, is the treatment of choice in cases of menorrhagia of menopause associated with fibromyomas not exceeding in size a four months' pregnancy, or of a fibrous uterus, in which the possibility of malignancy is eliminated by the history, or by a curettement. Small doses of radium are indicated in a few carefully selected cases of menorrhagia in young women of the child-bearing age.

2. A history or evidence of pelvic infection is a contraindication to the use of radium.

3. In adenomyomas which are adherent and difficult to remove, the use of radium is preferable to surgery.

4. Treatment with radium relieves the symptoms in certain cases of pruritus vulvae and in kraurosis associated with pruritus.

5. Endocervicitis continuing after an abdominal hysterectomy responds satis-

factorily to one or two treatments of radium.

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TECHNIQUE AND STATISTICS IN THE TREATMENT OF CARCINOMA OF THE UTERUS AND CONTIGUOUS ORGANS WITH THE COMBINED USE OF RADIUM AND X-RAYS*

BY HENRY SCHMITZ, M.D.

CHICAGO, ILLINOIS

At the last annual meeting of the society I presented a review of the investigations of Friedrich and Glasser[1] on the determination of isodoses or equal intensity curves of radium capsules. The outstanding facts of these researches were: (1) The calculation of the distribution of the dose from the laws of distance and absorption in the intratumoral treatment of cancer with radium is incorrect, as the secondary and scattered rays arising in the tissues and the geometrical form of the radium capsules have not been taken into account in such calculations. (2) The value of the secondary radiation is so great that it not only equals the loss by absorption, but results in higher values for the total dose. (3) The curves of equal intensities, designated "isodoses," do not take a course parallel to the circumference of the radium capsule, but evince a course deviating quite markedly from that of the surface of the capsule.

The capsules furnished by American purveyors of radium have a different construction from those employed by Friedrich and Glasser in their investigations. Therefore it appeared advisable to determine the equal intensity curves of some of the radium capsules in my possession. The results of these labors carried on in association with Huth[2] are shown in Figure 1. Knowing the equal intensity curves, it became necessary to determine

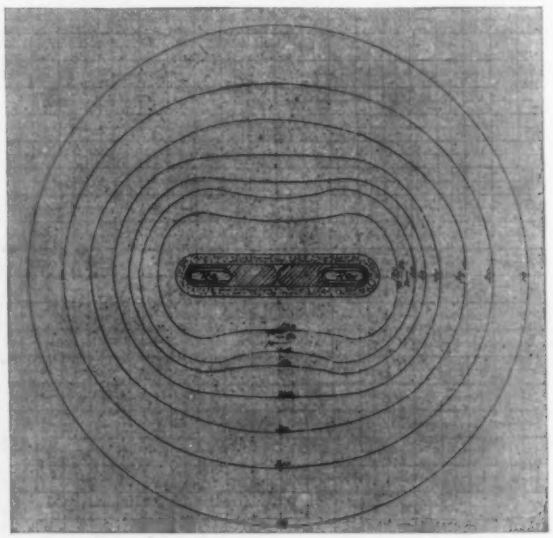

Fig. 1. Equal intensity curves of 50 mgm. element.

the time duration of the application of the 50 mgm. of radium element arranged and screened, as seen in Figure 1, to determine the biological unit of dose. For this purpose we chose the isodoses 60, 40, 20, 10

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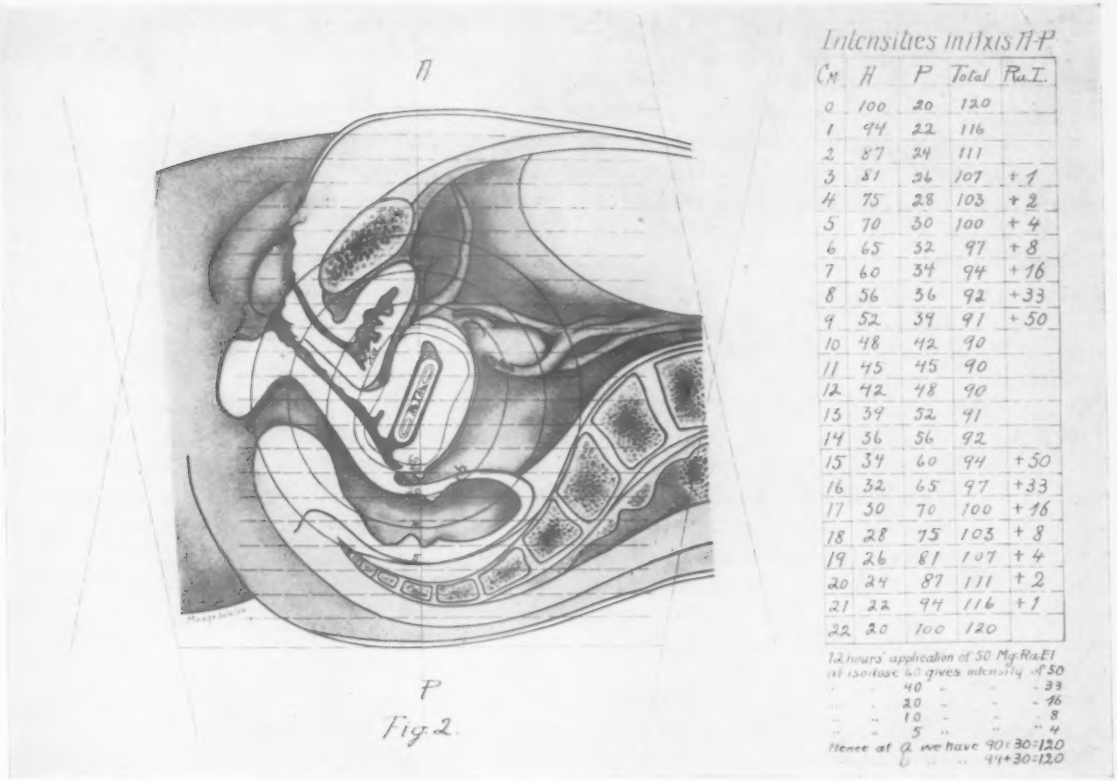


FIG. 2. Median longitudinal section of a female pelvis with equal intensity curves and intensities of x-rays.

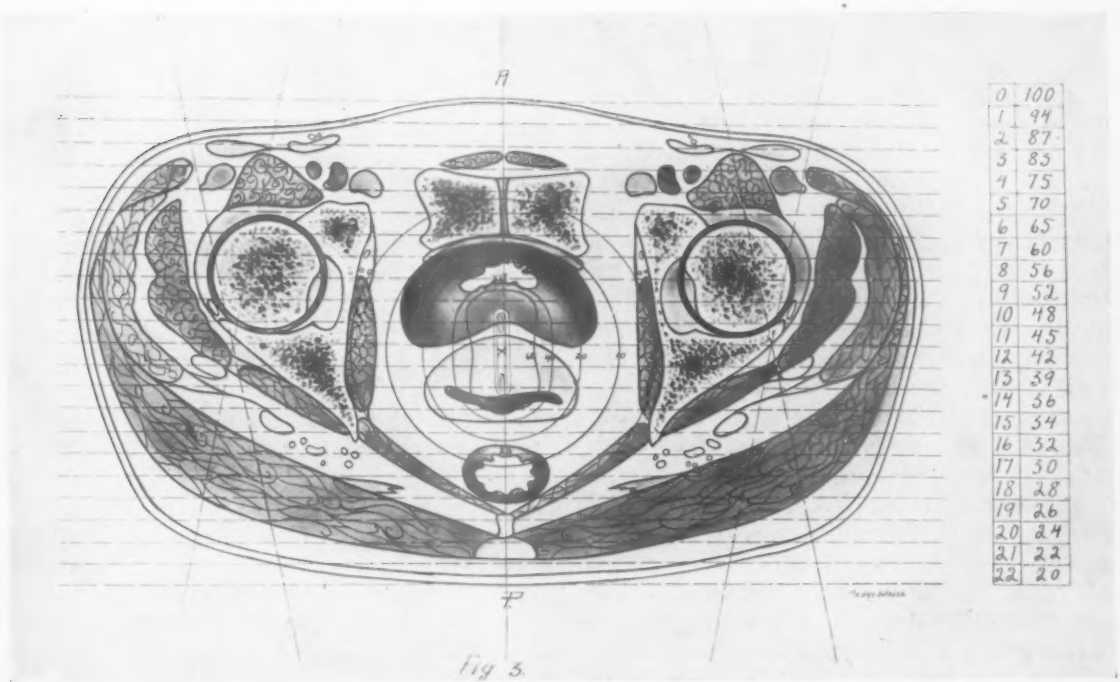


FIG. 3. Transverse section through cervix with equal intensity curves of radium and intensities of x-rays.

and 5, which are about 1, 2, 3, 4 and 5 cm. distant from the surface of the filter in the line vertical to the center of the longitudinal axis. The time duration of an application of 50 mgm. radium element within water at isodose 60 to obtain an erythema or epilation skin dose is about twenty-four hours, or 1,200 mgm. el. hrs.; at isodose 40 it is thirty-six hours, or 1,800 mgm. el. hrs.; at isodose 20 it is seventy-two hours, or 3,600 mgm. el. hrs.; at isodose 10 it is one hundred and forty-four hours, or 7,200 mgm. el. hrs.; and at isodose 5 it is two hundred and eighty-eight hours, or 14,400 mgm. el. hrs.

If an epilation skin dose of 1,800 mgm. el. hrs. has been applied to the equal intensity curve 40, then an intensity of 2,700 mgm. el. hrs. is attained at isodose 60; of 900 mgm. el. hrs. at isodose 20; of 450 mgm. el. hrs. at isodose 10, and of 225 mgm. el. hrs. at isodose 5. Since the epilation skin dose of 1,800 mgm. el. hrs. represents 100 per cent, Ep. S. D., isodose 60 receives 150, isodose 20 receives 50, isodose 10 receives 25 and isodose 5 receives 12.5 per cent of an Ep. S. D.

TECHNIQUE

The practical application of these investigations consists in drawing median longitudinal and transverse sections of the pelvis of the patient to be treated, as shown by Opitz and Friedrich.[3] The sections must be made from actual measurements of the patient(Figs. 2 and 3). The radium capsules are arranged in filters, as shown in Figure 1, and placed intrauterine on this drawing. The equal intensity curves 60, 40, 20, 10 and 5 are entered, using the patterns seen in Figure 4 which were made from the isodoses of Figure 1. We are now able to determine the exact intensities of radium rays in any part of the pelvis, provided we consider the time duration of the application of the radium which must be arranged and screened as shown above.

The intensity of rays to produce an epilation skin dose has been arbitrarily placed at 100. This represents the biological standard, or unit of a radiation dose. Reactions of tissues to radiations differ, depending on the intensity applied. Intensity varies with the amount of gamma rays, their geometrical distribution, the thickness and kind of filter, the focus skin distance, and the time of application. We distinguish the following reactions for normal epithelial cells:[4] (1) The maximal skin dose for healthy skin. It stops just short of a visible reaction. (2) The erythema or epilation skin dose produces a burn

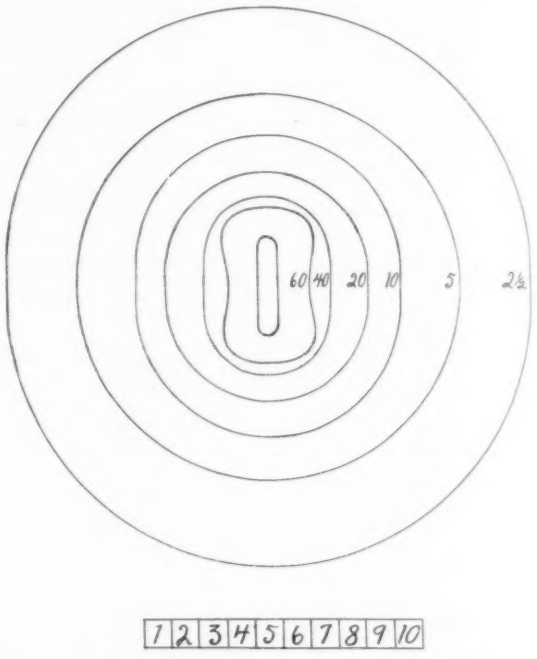


FIG. 4. Patterns of equal intensity curves of radium at 60, 40, 20, 10 and 5 per cent.

of the first degree. It is characterized by a reddish discoloration usually appearing at about the tenth to the fourteenth day after radiation, followed by a desquamation of the most superficial layers of the skin within about fourteen to twenty-eight days, and a loss of hair from about the twenty-eighth to the forty-second day. The skin recovers completely without any latent changes except a brownish discoloration which may last from six to eight months. (3) The estal skin dose is characterized by burns of the second degree accompanied by the formation of blisters. The latter heal promptly within six to eight weeks, leaving a white discoloration behind, in the area of which marked telangiectases appear in the course of a few months. (4) The lethal

skin dose which causes a third degree burn. It is characterized by a deep ulceration and subsequent necrosis, which may hea by aseptic methods of treatment or wil persist, necessitating finally excision and grafting with a pedicled flap of skin.

The maximal skin dose is attained at a distance of 1 cm. or isodose 60 in water with 50 mgm. radium element arranged and screened as shown in Figure 1 with an application of about eighteen hours; the epilation skin dose at twenty-four hours; the *aestal* skin dose at about thirty-two hours; and the lethal skin dose at about forty-eight hours. The lethal carcinoma dose is practically the same as the dose producing an epilation skin dose. Exceptions form the squamous cell carcinomata which respond to an estal skin dose. Carcinoma cells therefore are twice as sensitive to radiations as normal epithelial cells.[5]

The object of the treatment of cancer of the uterus with radiations is to degenerate or destroy all the cancer cells without permanent injury of the neighboring vital organs. The latter are the bladder and rectum. We may expose the epithelial cells of the posterior bladder mucosa and the anterior rectal mucosa to an intensity of 130 per cent. This is the highest intensity that we dare use. Higher intensities would bring these organs within the range of the lethal epithelial dose. The mucosae of the posterior bladder and anterior rectal walls are from 2 to 2½ cm. distant from the cervical canal. Hence, if we wish to avoid permanent injury or destruction of these regions we cannot extend the application of 50 mgm. radium element beyond thirty-six hours at 2 cm. and forty-eight hours at 2½ cm. The area within which this lethal cancer dose is attained is an ellipse about 4 cm. wide and 6 cm. long, namely, the isodose 40. Cancer cells beyond this ellipse are therefore not destroyed and beyond the isodose of 20 are actually stimulated to an increased mitosis, hence rapid growth.

The insertion of radium into the parametria through trochars, or the needling through a laparotomy incision have been tried by us in a number of cases.[6] The results did not warrant a continuation of the methods. Five laparotomies were performed for needling. Not a single patient appeared to be benefited. Only one patient, in whom radium was thrust into the parametrium through the vaginal fornix was apparently benefited.

The investigations of the determination of the equal intensity curves and the clinical observations on the reaction of gamma rays have convinced us that gamma rays are indicated when a local intensive effect suffices. As the majority of pelvic cancers have invaded the regional lymph-nodes, which are mostly 6 cm. distant from the cervical canal, we cannot reach all of the cancer cells with radium rays because we must avoid irreparable injuries to the normal tissues. We therefore studied the feasibility of combining radium therapy with *x*-rays. The latter are indicated where an extensive area must be subjected to radiations.[9]

Two types of transformers at our disposition have an output of 140 and 300 kv. respectively. The intensity of the *x*-rays depends on the proper determination of the following factors: The kilovoltage, the filter, the focus skin distance, the size of the field of entrance, the milliampèrage, the time duration of the application, and the roentgen-ray tube used. The tube employed with the 140 kv. transformer was a standard Coolidge tube with a bulb of a diameter of 18 cm.; while the one used with the 300 kv. transformer was the new therapy tube, the bulb measuring 21 cm. in diameter.

Two methods of measuring intensities of *x*-rays exist, the direct and the indirect. An example of the direct measurement is the Bachem electroscope. Indirect methods are the iontoquantimeter of Friedrich,[7] the measuring bench of Wintz and the electroscope of Schmitz. The Friedrich and Wintz instruments are modifications of Szillard's electrometer which was designed for the direct measuring of quantities of gamma rays of radioactive substances. We are using all the methods, as thereby we can control each instrument and thus be sure of the exactness of the measurements of radiation intensities. The introduction of these methods of determining radiation intensities has enabled the physician to solve the problem of a correct radiation therapy. The physician can now state

whether the diseased area is traversed by a practically homogeneous radiation. We can enter the *x*-ray intensities on the median longitudinal section. Figure 5 represents the intensities of the *x*-rays. The intensities of the 200 kv. *x*-rays are entered on the median section, seen in Figure 2, and by simple addition the physician may now determine the combined intensities necessary to destroy a pelvic carcinoma. Referring to Figure 2 we observe that the anteroposterior diameter is 22 cm. Two ports of entry are

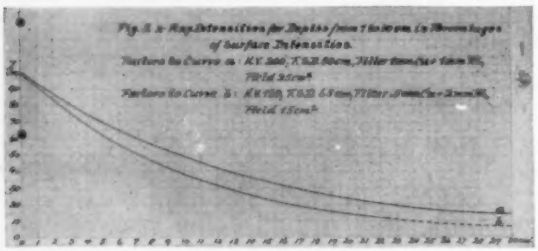


FIG. 5. *X*-ray intensity graphs with the chief factors.

used: A is the anterior and P the posterior port. The fields are 20 cm. square. The intensities of the *x*-rays for each cm. are read off from the graph *a* in Figure 5. They are shown in Figure 2 in the columns to the right of the section. By an addition of the gamma and *x*-ray intensities applied at the anterior rectal wall and posterior bladder wall, indicated by stars at *a* and *b*, the intensities to the right of the columns are attained. In this instance a 12 hours' application of gamma rays suffices. Should the combined intensities at either the bladder and rectal wall or on the skin amount to more than 130 occurring in patients with an anteroposterior diameter of less than 20 cm. we must reduce the application time of the gamma rays or *x*-rays or both. Should the intensities be less than 100 seen in patients with an anteroposterior diameter of more than 24 cm. we must increase the application of either the gamma rays or *x*-rays or both.

Figure 6 shows the application of the 140 kv. *x*-rays. Four fields are used: An anterior one of 20 cm. square, a posterior of 15 cm. square and left lateral and right lateral fields of 15 cm. square each. The last two fields are applied with the patient in either the right lateral or left lateral position, as seen in Figure 7. The axis of the lateral field is placed directly over the cervix. Attention must be given to leave a wide margin of skin between these lateral fields and the anterior and posterior fields. Points 1, 2, 3, 4 and 5 are now placed, as well as 6, 7, 8, 9, 10 and 11. The former present the anterior, posterior and lateral periphery and the center of the true pelvis; the latter, the skin regions where several *x*-ray beams cross each other. The last points are the danger points on the skin. The use of the Dessauer tables is particularly helpful with the 140 kv. *x*-rays.[8]

The preceding paragraphs represent the technique we employ in the treatment of carcinoma of the pelvic organs. The method with the 140 kv. *x*-rays and radium has been in use since 1919, while that of the 200 kv. *x*-rays and radium has been instituted since November, 1921. It is obvious that the statistics which follow do not as yet enable us to prove whether results will be improved by the newer method of radiation therapy.

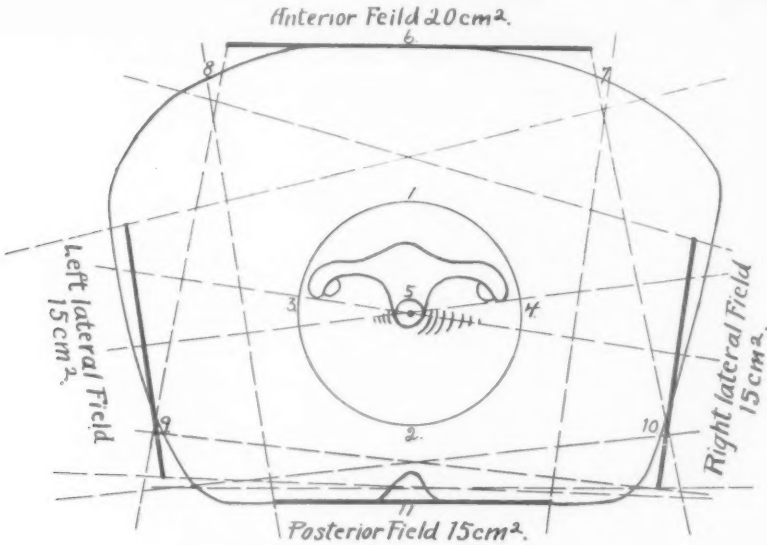
STATISTICS

The total number of cases of cancers of the female urogenital organs admitted and treated between the years 1914 and 1921 inclusive is 423. According to location and years they are divided as follows:

TABLE I

	1914	1915	1916	1917	1918	1919	1920	1921	Total	Per Cent
Vulva	..	..	2	..	..	4	2	2	10	2.3
Urethra	..	..	4	2	1	..	1	..	8	1.9
Bladder	3	4	..	4	6	9	5	6	37	8.6
Vagina	..	1	..	1	1	1	..	6	10	2.3
Cervix	12	31	42	24	38	45	60	51	303	72.0
Corpus	2	1	..	2	5	5	3	7	25	5.9
Ovaries	1	2	3	2	3	6	3	10	30	7.0
Total for each year	18	39	51	35	54	70	74	82	423	....

We did not refuse to treat a single case. However, the treatment varied, depending on whether the patient could be safely subjected to a curative application of the rays or not. As our experience grew, we also observed that clearly localized and borderline carcinomata offered a much better prognosis to radiation therapy than the clearly inoperable, recurrent and ad-



Intensities obtained at points marked.

Field	1	2	3	4	5	6	7	8	9	10	11
Ant.	40	135	25	25	225	100	80	80	12	12	105
L lat.	65	20	58	9	195				100		
R lat.	65	20	9	58	195					100	
Post	25	48	195	195	40	13	13	13			100
Total	98	101	117	117	105	113	93	93	112	112	105

Factors: 65cm. F.S.D., 0.5mm Cu + 6 mm. Leather + 1mm Al. Filter; 130 K.V. max., 5 mamp, Coolidge tube 18cm.; Time Duration of application to each Field i.e. Full Epilation Skin Dose 1050 M.amp. min.

FIG. 6. Transverse section of a female pelvis with four fields of entry for application of x-rays obtained with 130 kv. max. The factors are seen in Figure 5.

vanced cases.[9] For these reasons we divided the patients into five groups, namely: (1) The clearly localized cancer (2) the doubtfully localized cancer, (3) the inoperable cancer with invasion of the adjacent tissues or organs, the regional lymph-nodes or both, (4) the advanced case characterized by a "frozen pelvis" and grave cachexia, (5) the recurrent cancer, recurring after a surgical eradication. Table II represents the grouping of all the cases; the number of patients alive and well today are indicated in parentheses.

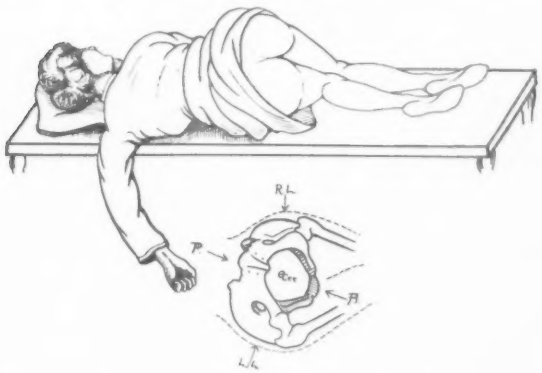


FIG. 7. A patient in left lateral position showing application of side fields.

We have tabulated all the cases that presented themselves. If the case refused treatment or did not complete the course of treatment, it was classed with the known dead. If inquiry remained unanswered, the case was added to those known to be dead. We therefore have applied the strictest rule to the statistics.

TABLE II

VULVA

Group	1914	1915	1916	1917	1918	1919	1920	1921	Total
Localized	....	....	1 (1)	....	....	1 (1)	....	....	2 (2)
Borderline	....	....	....	....	....	....	....	....	....
Inoperable	....	....	....	....	....	....	2 (2)	2 (2)	4 (4)
Advanced	....	....	....	....	....	1	....	....	1
Recurrent	....	....	1	....	....	2	....	....	3
Total	....	....	2 (1)	....	....	4 (1)	2 (2)	2 (2)	10 (6)

URETHRA

Group	1914	1915	1916	1917	1918	1919	1920	1921	Total
Localized	....	....	1 (1)	1 (1)	....	....	1 (1)	....	3 (3)
Borderline	....	....	....	....	....	....	....	....	....
Inoperable	....	....	3	1	1 (1)	....	....	....	5 (1)
Terminal Advanced	....	....	....	....	....	....	....	....	....
Recurrent	....	....	....	....	....	....	....	....	....
Total	....	....	4 (1)	2 (1)	1 (1)	....	1 (1)	....	8 (4)

VESICA

Group	1914	1915	1916	1917	1918	1919	1920	1921	Total
Localized	....	1 (1)	....	....	1 (1)	....	....	....	2 (2)
Borderline	....	....	....	....	....	....	....	....	....
Inoperable	....	....	....	....	3	7 (1)	2	1 (1)	13 (2)
Advanced or Terminal	2	....	....	3	2	1	2	3 (1)	13 (1)
Recurrent	1	3	....	1	....	1	1	2 (2)	9 (2)
Total	3	4 (1)	....	4	6 (1)	9 (1)	5	6 (4)	37 (7)

VAGINA

Group	1914	1915	1916	1917	1918	1919	1920	1921	Total
Localized	....	....	....	1 (1)	....	....	....	....	1 (1)
Borderline	....	....	....	....	....	1	....	....	1
Inoperable	....	1	....	....	....	....	....	4 (3)	5 (3)
Terminal	....	....	....	....	....	....	....	2	2
Recurrent	....	....	....	....	1 (1)	....	....	....	1 (1)
Total	....	1	....	1 (1)	1 (1)	1	....	6 (3)	10 (5)

CERVIX

Group	1914	1915	1916	1917	1918	1919	1920	1921	Total
Localized	....	1 (1)	1 (1)	....	1	2 (2)	4 (3)	4 (4)	13 (11)
Borderline	1	4 (1)	5 (3)	2	4 (2)	2 (1)	4 (3)	4 (4)	26 (14)
Inoperable	7	15	10 (1)	13 (4)	14 (2)	18 (5)	20 (7)	17 (12)	114 (31)
Terminal	....	4	9	6	8	10 (1)	21 (2)	17 (7)	75 (10)
Recurrent	4	7	17 (1)	3	11 (1)	13 (1)	11 (3)	9 (5)	75 (11)
Total	12	31 (2)	42 (6)	24 (4)	38 (5)	45 (10)	60 (18)	51 (32)	303 (77)

CORPUS

Group	1914	1915	1916	1917	1918	1919	1920	1921	Total
Localized	1 (1)	....	....	1	3 (3)	1 (1)	1 (1)	1 (1)	8 (7)
Borderline	....	....	....	....	1 (1)	....	....	3 (2)	4 (3)
Inoperable	1	....	....	1	1	1	....	....	4 ....
Terminal	....	1	....	....	....	....	....	2 (1)	5 (1)
Recurrent	....	....	....	....	....	2	1 (1)	1	4 (1)
Total	2 (1)	1	....	2	5 (4)	5 (1)	3 (2)	7 (4)	25 (12)

OVARIES

Group	1914	1915	1916	1917	1918	1919	1920	1921	Total
Localized	....	....	....	....	....	....	....	....	....
Borderline	....	....	....	....	....	....	....	....	....
Inoperable	1	....	1	1	2 (1)	3 (2)	3	6 (4)	17 (7)
Terminal	....	....	....	....	....	....	....	1	1
Recurrent	....	2	2	1	1	3	....	3 (1)	12 (1)
Total	1	2	3	2	3 (1)	6 (2)	3	10 (5)	30 (8)

In Table III the cases are tabulated that have passed the five-year limit, namely, those from 1914 to 1917 inclusive.

If only the operable and borderline cases of all the locations are considered, we have 25 cases with 12 absolute recoveries, namely, 48 per cent.

Considering only the cervical cancer we have a total of 109 with 12 five-year cures, namely, 11.1 per cent. The localized and borderline cervix cases with a five-year cure number 14 with 6 survivors, namely, 42.8 per cent.

TABLE III

Location	Group	1914	1915	1916	1917	Total	Per Cent
Vulva	Localized	.....	.....	1 (1)	.....	.....	100
	Recurrent	.....	.....	1	.....	.....	0
Urethra	Localized	.....	.....	1 (1)	1 (1)	.....	100
	Inoperable	.....	.....	3	1	.....	0
Vesicae	Localized	.....	1 (1)	.....	.....	.....	100
	Terminal	2	.....	.....	3	.....	0
	Recurrent	1	3	.....	1	.....	0
Vagina	Localized	.....	.....	.....	1 (1)	.....	100
	Inoperable	.....	1	.....	.....	.....	0
Cervix	Localized	.....	1 (1)	1 (1)	.....	2 (2)	100
	Borderline	1	4 (1)	5 (3)	2	12 (4)	33.3
	Inoperable	7	15	10 (1)	13 (4)	45 (5)	9
	Terminal	.....	4	9	6	19	0
	Recurrent	4	7	17 (1)	3	31	3.5
	Total	12	31 (2)	42 (6)	24 (4)	109 (12)	11.1
Corpus	Localized	1 (1)	.....	.....	1	2 (1)	50
	Inoperable	1	1	.....	1	3	0
Ovaries	Inoperable	1	.....	1	1	.....	0
	Recurrent	.....	2	2	1	.....	0

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THE EFFECT OF THE SIZE OF RADIUM APPLICATORS ON SKIN DOSES*

BY EDITH H. QUIMBY, M.A.

Radium Research Laboratory, Memorial Hospital

NEW YORK CITY

FOR a point source of radiant energy, it is a well-known physical law that radiation varies inversely as the square of the distance from the source. When the source is not a point, this is not strictly true, and when it is a fairly large surface it is not even approximately so, for distances comparable to the size of the source.

In radium therapy the applicators used frequently have areas of several square centimeters, and are used close to the skin. For purposes of dosage it is desirable to compare the intensity of radiation delivered by different applicators at different distances. The inverse square law offers only a first approximation in this case. Therefore the tables included in this paper have been worked out, so that doses may be compared directly, for the applicators and distances considered. Furthermore, by means of the curves, the comparison may be made for any practical applicators and any distances. Also, if the dose is known for one applicator, under a given set of conditions of distance and filtration, it may be obtained for any other applicator, under any conditions of application.

If we consider a line, which is the simplest departure from a point source, and which corresponds for all practical purposes to a tube applicator, we have the situation shown in Figure 1.

AB is the source of radiation, and we wish to find the intensity at P, which is at a distance *d* units from its center. If the source of strength Q_0, were concentrated at S, the intensity at P would be $\frac{kQ_0}{d^2}$, where k is a constant depending on the units adopted.

But the radioactive source is uniformly distributed over AB, and every point of AB except its center is at a greater distance than *d* units from P. Therefore, as we would expect, the intensity at P is less in this case than in the case of the point source. We may consider any tube to be divided into a definite number of point sources of equal intensity, for instance, ten. Then the intensity due to each point source can be calculated according to the inverse square law, and the sum of all these will be the intensity for the tube. To simplify the calculations, this was done in the present case. For a tube of length *a* units, ten points were taken, at distances of 0.05*a*, 0.15*a*, 0.25*a*, 0.35*a*, and 0.45*a* units on either side of the center, as

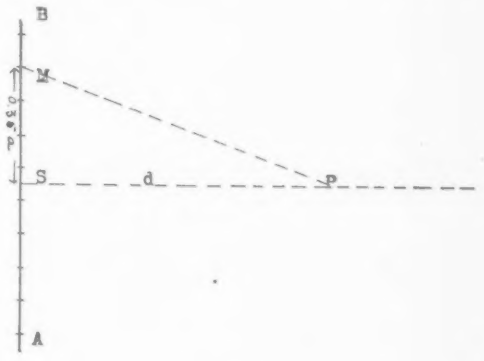


FIG. 1.

indicated in the figure. The intensity of radiation at P due to any one of these sources is determined directly by the inverse square law. For instance, for the point M, which is at a distance 0.35*a* units from S, the intensity is $\frac{1}{10}\frac{kQ_0}{(MP)^2}$ which is equal to $\frac{1}{10}\frac{kQ_0}{(0.35a)^2 + d^2}$. The sum of the intensities at P due to the ten point sources is, for all practical purposes, the same as the intensity due to a line source.

For a flat circular applicator of diameter *a* units, one hundred points were considered instead of ten. Circles were drawn at distances 0.05*a*, 0.15*a*, 0.25*a*, 0.35*a*, 0.45*a* units from the center, and the points equally spaced on these. Then all the points on any one circle are at the same

* This article was received for publication in November, 1921.

distance from the point at which we are measuring the intensity. The intensity of radiation due to a point source on each circle was determined in the manner previously explained; this was multiplied by the number of points on that circle, and the sum of all these products taken as the intensity for the circular applicator. In the case of the square and rectangular applicators a similar method was used.

If a filter is introduced between the source and the point P, the radiation suffers an additional decrease due to absorption

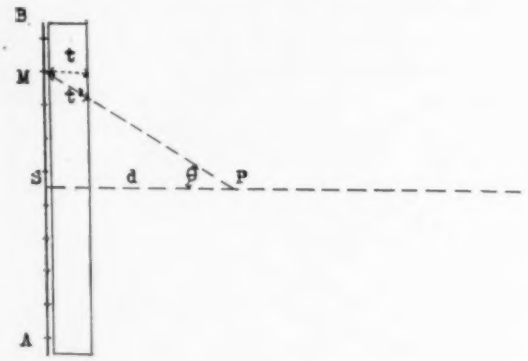


FIG. 2.

in the material of the filter. In order to find the intensity due to a point source, when a filter is interposed, we may simply take that fraction of the unfiltered radiation which is transmitted by the given thickness of material. But in the case of a distributed source, the thickness of filter traversed by radiation from different parts is not the same. That from a point near the edge passes through a greater thickness of material than that from a point near the center. This is shown in Figure 2, from which we see that t', the actual thickness traversed, will be equal to $\frac{t}{\cos\theta}$. Therefore in determining the intensity due to any one of the individual points we must include a factor $R_{t'}$, the fraction of the initial radiation transmitted by this thickness of filter, e.g., the intensity at P due to the point M is equal to $\frac{I}{10}\frac{kQ_0R_{t'}}{(0.35a)^2+d^2}$. If we have an absorption curve for the metal of the filter, showing the percentage of the transmitted radiation relative to the unfiltered source, for different thicknesses of metal, the values of $R_{t'}$ may be read directly from it. Such curves have been published in a previous paper.[1] These curves are, however, based on physical data, that is, measurements of the ionization produced by the filtered radiation. Since the applications of the present paper are to biological effects, it is best to use as a basis for calculations, a curve obtained by finding, for different filters, the amount of radiation which produced a definite biological result. Therefore the number of millicurie-hours necessary to produce an "average erythema"[2] was determined, for a number of different thicknesses of brass. For the same number of millicuries, the time required to produce the erythema is inversely proportional to the amount of radiation transmitted by the filter. Hence, the reciprocals of the times, plotted against the corresponding thicknesses of filter, give a curve which is better for determining doses than one based on ionization measurements. This is given in Figure 3. The doses from which it is plotted are shown in Table I.

TABLE I

Curve showing intensities of radiation required to produce erythema, for different filters, in terms of intensity from unfiltered source. Radium applied at distance of 2 cm. from skin

Total Filter in Addition to Glass Tube	Dose, Mc.-hr.	$\frac{i}{\text{Dose}}$	Percentage
None	7.5	0.1333	100.0
0.16 mm. brass	30.0	0.0333	40.0
1.2 mm. rubber	.....	.....	.....
0.32 mm. brass	100.0	0.0100	7.50
1.2 mm. rubber	.....	.....	.....
0.50 mm. brass	250.0	0.0040	3.00
1.2 mm. rubber	.....	.....	.....
0.75 mm. brass	475.0	0.0021	1.57
2.4 mm. rubber	.....	.....	.....
1.0 mm. brass	630.0	0.0016	1.20
2.4 mm. rubber	.....	.....	.....
2.0 mm. brass	830.0	0.0012	0.90
2.4 mm. rubber	.....	.....	.....

[1] The Effect of Different Filters on Radium Radiations, AM. J. OF ROENTGENOL., September, 1920.

[2] An "average erythema" is defined as the erythema produced on the skin of the average patient by a dose of 7.5 millicurie-hours of unfiltered radiation, applied at a distance of 2 cm. By unfiltered radiation is meant the radiation from the emanation in the capillary glass tube, with no additional covering.

Note For unfiltered radiation, the integral calculus offers a convenient method of attacking this problem. The expression for the tube is

$$I_p = 2\int_0^{\frac{a}{2}} \frac{KQ_0 dx}{p^2 + x^2} = \frac{2K}{p} \tan^{-1} \frac{x}{p}.$$

This formula has been used by Wood and Prime (Action of Radiation on Transplanted Tumors in Animals. *Ann. of Surg.*, Dec., 1915).

But when the term for the filter is introduced, the expression becomes

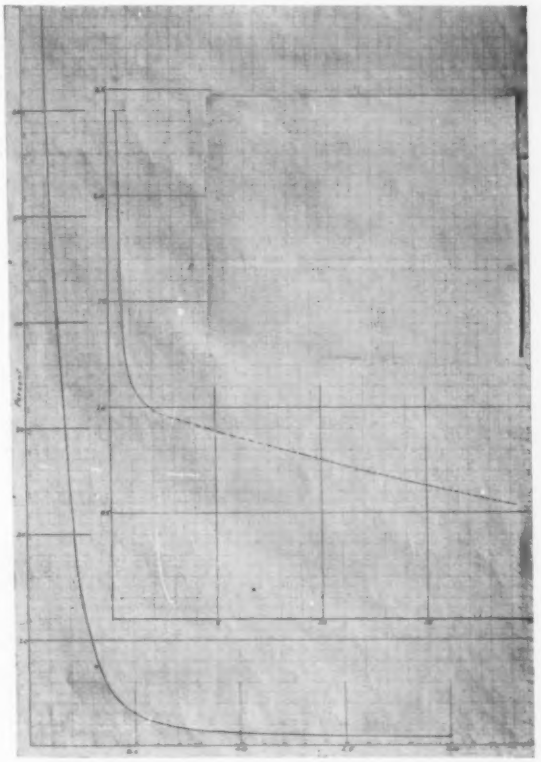
$$I_p = 2\int_0^{\frac{a}{2}} KQ_0 C^{-\mu d \sec \theta} d\theta$$

which is not readily integrated. In any case the method is not applicable for filters less than 2 mm. of brass. In order to integrate the expression, μ, the absorption coefficient must be regarded as constant. But this is not the case unless the absorption follows an exponential law. It has been shown that a filtration of at least 2 mm. of brass is necessary in order for this condition to be fulfilled. (Failla. The absorption of radium radiations by tissue, AM. J. ROENTGENOL., May, 1921.)

The term cos θ, which appears in expressions for the intensity of light, is omitted in these expressions. What we are really interested in is not the intensity, but the energy density per small unit volume, and this does not depend on the angle.

In order to obtain results which could be used for applicators of various sizes, the unit adopted for measuring all distances was an arbitrary constant a, which represents the length of the tube, the diameter of the circle, the side of the square, or the shorter side of the rectangle (the longer side being $1.5a$) as the case may be. All calculations were made in terms of this unit, so that the curves are general. The filters considered were: Bare applicators,[3] Figure 4; 0.16 mm. brass, Figure 5; 0.50 mm. brass, Figure 6; 0.75 mm. brass, Figure 7; and 2.0 mm. brass, Figure 8. In each chart, separate curves are given for the tube, circle, square, and rectangle. The horizontal distances denote distance from applicator to skin, the vertical distances give the intensity of radiation from the given applicator, in percentage of the intensity from a point source of the same strength at the same distance. Since the effect due to the point source is easily calculated by the inverse square law, it will be seen that when we have obtained a relation between a given applicator and the point source, we can readily find the effect due to the applicator. For any given applicator at a definite distance, it is necessary to express the distance in terms of a for that applicator. This then enables us to read from the curve the effect due to that applicator at the specified distance, relative to that from a point source at the same distance. Having calculated the effect of the point source at this distance, we have only to take the percentage of it indicated by the reading on the curve.

[3] A "bare applicator" is one having no additional filter beyond the glass of the emanation tube.



Millimeters Brass.

FIG. 3. Curve showing intensities of radiation required to produce erythema, for different filters, in terms of intensity from unfiltered sources. Dotted curve shows portion near bend much enlarged.

It should be noted that the intensity obtained is that at a point on the axis of the applicator. Except for a few special cases, which will be mentioned later, intensities at other points have not been calculated. The one given is evidently the maximum, since the average distance to it from all points on the applicator is less than from any other. If it is a question of how much radiation can be applied without causing injury, it is this maximum effect which must be known.

Let us consider some examples of the use of the curves; 1. What is the effect

due to an applicator 4 cm. square, at a distance of 3 cm. from the skin, the filter being 2 mm. of brass and 2.4 mm. of rubber? a is 4 cm., hence the distance, 3 cm., is $0.75a$. For a filter a 2 mm. of brass we refer to Figure 8. The effect due to a square at a distance of $0.75a$ is 77.3 per cent of that for a point source at the same distance. So if we had attempted to use this applicator and calculate the dose by the inverse square law alone, we would have given 100 − 77.3 = 22.7 per cent too small a dose of radiation.

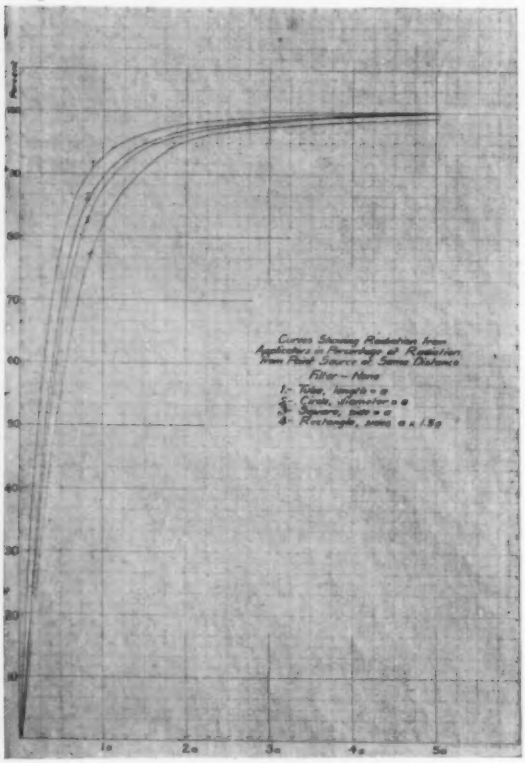

Curves Showing Radiation from Applicators in Percentage of Radiation from Point Source at Same Distance
Filter – None
1- Tube, length = a
2- Circle, diameter = a
3- Square, side = a
4- Rectangle, sides a x 1.5a
Percent
Distance from skin.

FIG. 4.

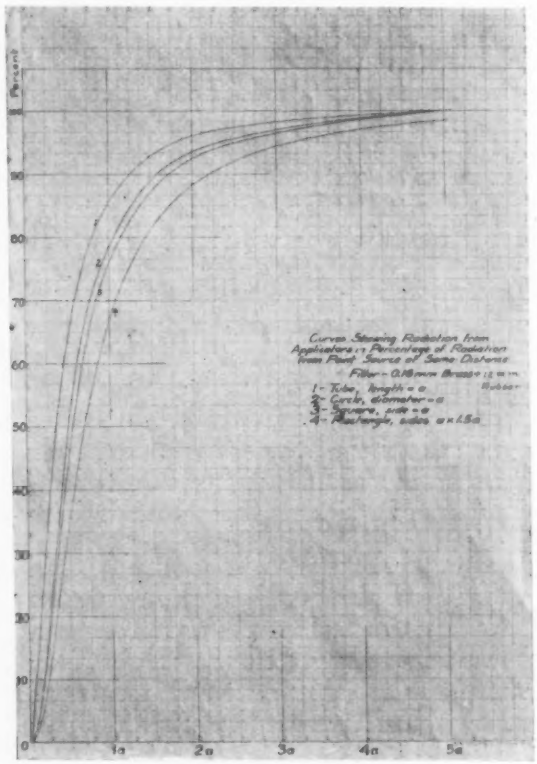

Curves Showing Radiation from Applicators in Percentage of Radiation from Point Source at Same Distance
Filter – 0.18 mm Brass + 1.8 mm Rubber
1- Tube, length = a
2- Circle, diameter = a
3- Square, side = a
4- Rectangle, sides a x 1.5a
Percent
Distance from skin.

FIG. 5.

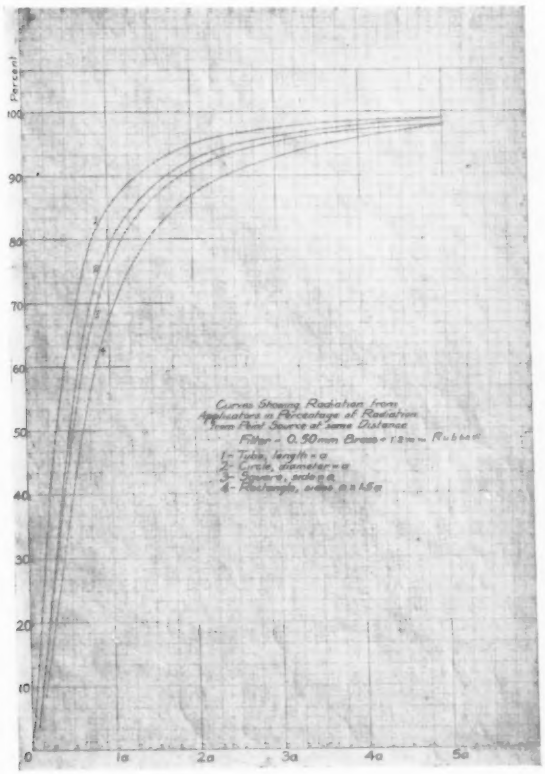
2. Suppose we have an applicator which does not fit any one curve, for instance, a rectangle whose dimensions are not a x $1.5a$. It is possible to interpolate between two curves. What is the effect due to a rectangle 6 x 8 cm. at a distance of 5 cm., the filter being 0.75 mm. of brass and 2.4 mm. of rubber? In curves 7 we have the square a x a, and the rectangle, a x $1.5a$, and our applicator falls between the two. a is 6 cm., the distance (5 cm.) is $0.83a$. For the square at this distance the value is 75.1 per cent, and for the rectangle 66.3 per cent of that from the point source. For the applicator under consideration, if we take the mean of these two, 70.7 per cent, we will not be far wrong.

3. How do the effects due to the following two applicators compare:—(a) a circle 5 cm. in diameter, at a distance of 3 cm., and (b) a rectangle 6 x 8 cm., at a distance of 6 cm; the filter in each case being 2 mm. of brass and 2.4 mm. of rubber, and the quantity of radium, and the time used in each case being the same? The proper curves for this case are Figure 8. For the circle a is 5 cm., the distance (3 cm.) is $0.6a$, the value for the circle at this distance is 75.3 per cent of that from the point at the same distance. For the rectangle, a is 6 cm. and the distance (6 cm.) is a. The value in this case is 81.0 per cent that of the point source at

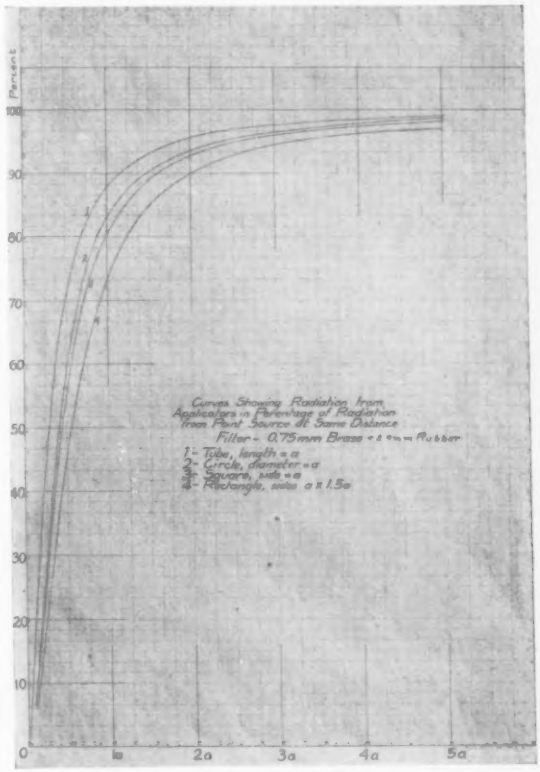
the same distance. But the intensity of radiation due to the point source at 3 cm. is $\frac{1}{9}$ that at 1 cm., and at 6 cm. $\frac{1}{36}$ that at 1 cm., according to the inverse square law. So if we adopt the effect due to the point at 1 cm. as a unit, the circle at 3 cm. will give $\frac{1}{9} \times 75.3$ per cent = 8.39 per cent, and the rectangle at 6 cm. will give $\frac{1}{36} \times 81.0$ per cent = 2.25 per cent.

TABLE II

Filter	Filtration Factor
None (glass capillary)	1.00
0.16 mm. brass + 1.2 mm. rubber	0.40
0.50 mm. brass + 1.2 mm. rubber	0.030
0.75 mm. brass + 2.4 mm. rubber	0.0157
2.0 mm. brass + 2.4 mm. rubber	0.0090



Distance from skin.
FIG. 6.



Distance from skin.
FIG. 7.

Whence, of our two applicators, the circle gives $\frac{8.41}{2.25} = 3.8$ times as much radiation at the given distance.

Values from 2 sets of curves are not comparable, since each set is based upon a different value for 100 per cent, namely the effect due to the point source with the same filter as for that set of applicators. However, with the aid of the following filtration factors, values from the various curves may be compared by multiplying each by its proper factor:

4. For instance, what is the difference in the intensity of radiation from a 2 x 2 cm. applicator having a filter of 0.16 mm. brass and 1.2 mm. of rubber, at a distance of 2 cm., and from one 4 x 6 cm., having a filter of 0.50 mm. brass and 1.2 mm. of rubber at a distance of 4 cm.? For the first, we use Figure 5, and for the second, Figure 6. For the square, $a = 2$, the distance is a, the value from the curve is 76.0 per cent that of the point at the same distance. At 2 cm. the value for the point is $\frac{1}{4}$ that at 1 cm. Therefore the value for

the square is ¼ x 76.0 or 19.0 per cent that of the point at 1 cm. Multiplying by the filtration factor from Table II, 0.40, we have 7.6 per cent. For the rectangle, $a = 4$, the distance is a, the value is 67.7 per cent that of the point at the same distance, and 1/16 as much, or 4.23 per cent that of the point at 1 cm. Multiplying by the factor from Table II, 0.030, we have 0.127

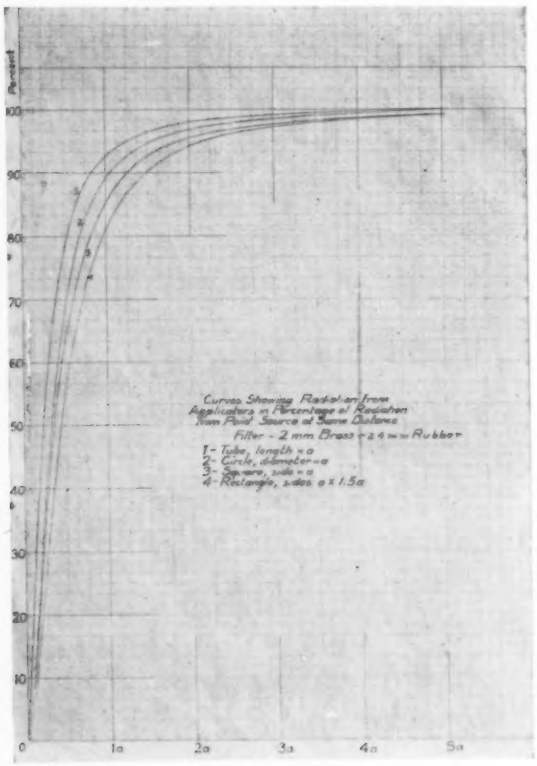

Curves Showing Radiation from Applicators in Percentage of Radiation from Point Source at Same Distance
Filter - 2 mm Brass + 2.4 mm Rubber
1- Tube, length = a
2- Circle, diameter = a
3- Square, side = a
4- Rectangle, sides a x 1.5a
Distance from skin.

FIG. 8.

per cent. Whence, for these applicators and distances the square with 0.16 mm. brass gives $\frac{7.6}{0.127}$ or 60 times as much radiation as the rectangle with 0.50 mm. brass.

5. By means of these curves, if the dose for one applicator is known, that for another can be found. Suppose that, for a circular applicator 3 cm. in diameter, at a distance of 3 cm., filter 0.75 mm. brass + 2.4 mm. rubber, the dose is 700 millicurie-hours. What is it for a rectangle 4 x 6 cm., at a distance of 4 cm., the filter being the same? Comparing the two applicators in the manner outlined in example 4, we find the effect due to the rectangle to be 0.5 that due to the circle. Therefore in order to produce the same effect, it is necessary to double the dose in millicurie-hours in the case of the rectangle.

6. If a tube 1.4 cm. long, placed 2 cm. from the skin, with a filter of 0.5 mm. brass and 1.2 mm. of rubber, produces an erythema with a dose of 250 millicurie-hours, what dose will be necessary to produce the same effect with a circular applicator 3 cm. in diameter at a distance of 2 cm., the filter being 0.16 mm. brass and 1.2 mm. rubber? In this case it is again necessary to use the factors of Table II. The value for the tube, (a = 1.4 cm., distance = 1.43a) is 91.0 per cent x ¼ x 0.030, or 0.682 per cent. For the circle (a = 3 cm., distance = 0.67a), it is 64.3 per cent x ¼ x 0.40 or 6.43. Therefore the value from the circle is $\frac{6.43}{0.682} = 9.4$ times that from the tube; the dose to produce the same effect is $\frac{250}{9.4}$ or 26.6 millicurie-hours.

Since it is frequently desired to compare doses, and the operation here outlined is rather complicated, it was thought desirable to calculate from these curves tables for certain definite applicators and definite distances, so that a comparison might be made directly. These are given in Table III. The effect due to the point source of unit strength, without filter, at a distance of 1 cm. is called 100, and all the other values are in terms of this standard. Therefore they are all directly comparable. It will be seen that in each case the calculations have been carried out for practical distances for the given applicator.

Now if we take example 4, and look in Table V for a 2 x 2 cm. square, filter 0.16 cm. brass + 1.2 mm. rubber, distance 2 cm., we find a value of 7.6; for a 4 x 6 cm. rectangle, filter 0.50 mm. brass, + 1.2 mm. rubber, distance 4 cm., we find a value of 0.126, which are just what we found previously from the curves.

Similarly, with Example 6: The value for the tube 1.4 cm. long would be about halfway between that of one 1.0 cm. long and one 2.0 cm. long. For a filter of 0.5 mm. brass and 1.2 mm. rubber, at a distance of

TABLE III

INTENSITIES OF RADIATION FROM DEFINITE APPLICATORS AT DEFINITE DISTANCES; POINT SOURCE, WITH SAME FILTER, AT DISTANCE OF 1 CM. = 100 UNITS IN EACH OF THE FOLLOWING SUBDIVISIONS

A—*Applicators without filter*

Distance, cm.	Point	*Tubes*—Length		*Circles*—Diameter					
		1 Cm.	1.5 Cm.	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.
0.25	1,600.0	890.0	672.0	656.0	283.0	106.0	57.6	41.6	25.8
0.50	400.0	314.0	262.0	279.0	164.0	70.8	40.0	26.4	19.9
0.75	178.0	157.0	140.0	148.0	103.0	52.8	31.5	21.4	15.3
1.0	100.0	92.8	89.3	89.6	69.7	41.0	25.6	17.7	13.3
1.5	44.4	43.2	41.2	42.4	37.1	25.7	18.2	13.1	10.0
2.0	25.0	24.5	23.9	24.3	22.4	17.4	13.3	10.2	8.02
3.0	11.1	11.0	10.9	10.9	10.6	9.27	7.74	6.42	5.45

	Squares—Lengths of Side								
	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.			
0.25	606.0	261.0	96.0	52.8	40.0	24.4	.....	.....	.....
0.50	265.0	152.0	65.2	36.0	24.0	18.5	.....	.....	.....
0.75	145.0	97.0	48.4	29.0	19.4	13.9	.....	.....	.....
1.0	87.5	66.2	37.9	23.6	16.3	12.2	.....	.....	.....
1.5	42.0	36.2	24.2	16.8	12.1	9.24	.....	.....	.....
2.0	24.1	21.9	16.6	12.4	9.48	7.38	.....	.....	.....
3.0	10.9	10.5	9.06	7.35	6.05	5.04	.....	.....	.....

	Rectangles—Lengths of Sides								
	1 × 1.5 Cm.	2 × 3 Cm.	4 × 6 Cm.	6 × 8 Cm.	8 × 12 Cm.	10 × 15 Cm.			
0.25	478.0	195.0	70.5	35.2	20.8	15.0	.....	.....	.....
0.50	227.0	119.0	48.8	26.8	17.2	12.1	.....	.....	.....
0.75	130.0	79.5	37.8	21.7	14.2	10.3	.....	.....	.....
1.0	82.0	56.8	29.8	18.0	12.2	8.62	.....	.....	.....
1.5	40.4	32.4	19.8	13.2	9.40	6.68	.....	.....	.....
2.0	23.8	20.5	14.2	10.0	7.45	5.52	.....	.....	.....
3.0	10.8	10.1	8.10	6.30	4.95	4.01	.....	.....	.....

2 cm., this factor is 0.685. The factor for the circle 3 cm. in diameter at a distance of 2 cm., filter 0.16 mm. brass and 1.2 mm. of rubber, is 6.42. Therefore for the same dose the circle would produce $\frac{6.42}{0.685}$ or 9.4 times the effect. But since the same effect is desired, we must decrease the dose from the circle; it should be $\frac{250}{9.4}$ or 26.6 millicurie-hours.

Suppose we wish to compare the intensity of radiation on the skin from a dose of 500 millicurie-hours given with a circular applicator 3 cm. in diameter, filter 0.5 mm. brass and 1.2 mm. rubber, distance 2 cm. with that from a dose of 2000 millicurie-hours from a rectangular applicator 4 x 6 cm., filter 2.0 mm. brass and 2.4 mm. rubber, distance 4 cm. The factor for the first is 0.48 (assuming the 3 cm. applicator to have the average of the 2 and 4 cm. ones). Since this is per unit of dose,

TABLE III

B—*Applicators with filter of 0.16 mm. brass, and 1.2 mm. rubber*

Distance, Cm.	Point	*Tubes*—Length			*Circles*—Diameter					
		1 Cm.	2 Cm.	4 Cm.	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.
0.25	640.0	235.0	132.0	51.2	126.0	34.6	10.2	5.76	3.20	1.07
0.50	160.0	103.0	57.2	33.0	80.8	31.4	8.64	4.00	2.56	1.78
0.75	71.2	55.6	37.2	20.5	49.2	25.7	8.40	3.85	2.35	1.50
1.0	40.0	34.6	25.8	14.7	31.2	20.2	7.84	3.72	2.16	1.40
1.5	17.8	16.6	13.9	9.28	15.8	12.3	6.24	3.48	2.10	1.37
2.0	10.0	9.62	8.56	6.44	9.36	7.80	5.04	3.04	1.96	1.33
3.0	4.44	4.38	4.12	3.48	4.31	3.91	3.08	2.24	1.44	1.15
		Squares—Length of Side								
		1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.			
0.25		114.0	36.0	9.60	5.76	3.20	1.05	.....	....	....	....
0.50		74.0	28.5	8.00	3.68	2.40	1.74	.....	....	....	....
0.75		46.4	23.4	7.60	3.59	2.06	1.35	.....	....	....	....
1.0		30.4	18.5	7.12	3.40	2.00	1.32	.....	....	....	....
1.5		15.5	11.6	5.84	3.16	1.90	1.21	.....	....	....	....
2.0		9.24	7.60	4.64	2.76	1.78	1.20	.....	....	....	....
3.0		4.28	3.87	2.91	2.05	1.46	1.06	.....	....	....	....
		Rectangles—Lengths of Sides								
		Cm. 1 × 1.5	Cm. 2 × 4	Cm. 4 × 6	Cm. 6 × 9	Cm. 8 × 12	Cm. 10 × 15			
0.25		76.0	20.5	5.44	1.92	1.28	0.56	.....	....	....	....
0.50		56.8	19.1	5.12	2.40	1.44	0.92	.....	....	....	....
0.75		38.4	17.3	4.92	2.28	1.32	0.86	.....	....	....	....
1.0		26.9	14.2	4.76	2.20	1.28	0.80	.....	....	....	....
1.5		14.4	9.60	4.32	2.11	1.22	0.78	.....	....	....	....
2.0		8.84	6.72	3.54	2.03	1.19	0.78	.....	....	....	....
3.0		4.20	3.60	2.40	1.57	1.08	0.77	.....	....	....	....

or, in other words, per millicurie-hour, this must be multiplied by the dose: 0.48 x 500 = 240. Similarly, for the rectangle the factor is 0.045. Multiplying this by the dose we have 90.0. Therefore the first applicator would give $\frac{240}{90}$ or 2.7 times as intense radiation on the skin as the second.

It should be noted that in these curves and tables the decrease in intensity of radiation given is due to increase in distance alone. If it is desired to consider the effect within the body, then the decrease due to absorption by tissue enters, and proper allowance must be made for this. At the present time, however, we do not know with any degree of accuracy the amount of radiation which reaches the deep layers of tissue.

According to the method outlined in Example 6, using the clinical doses given at Memorial Hospital as a basis for the calculations, a table (Table IV) of the dose.

TABLE III

C—Applicators with filter of 0.50 mm. brass, and 1.2 mm. rubber

Distance, Cm.	Point	*Tubes*—Length			*Circles*—Diameter					
		1 Cm.	2 Cm.	4 Cm.	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.
0.50	12.0	7.60	4.68	2.28	5.34	3.68	1.03	0.52	0.32	0.24
0.75	5.34	4.17	2.83	1.62	3.66	1.94	0.82	0.46	0.28	0.19
1.0	3.00	2.60	1.90	1.17	2.36	1.49	0.70	0.39	0.26	0.18
1.5	1.33	1.22	1.04	0.71	1.17	0.91	0.48	0.30	0.20	0.15
2.0	0.75	0.71	0.64	0.47	0.69	0.59	0.37	0.24	0.17	0.13
3.0	0.333	0.32	0.30	0.20	0.32	0.29	0.23	0.16	0.12	0.09

	Squares—Length of Side									
	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.				
0.50	5.52	2.52	0.97	0.48	0.29	0.23	....	....	....	....
0.75	3.54	1.84	0.77	0.43	0.26	0.18	....	....	....	....
1.0	2.26	1.38	0.63	0.37	0.24	0.16	....	....	....	....
1.5	1.15	0.88	0.46	0.28	0.19	0.14	....	....	....	....
2.0	0.68	0.56	0.34	0.22	0.16	0.12	....	....	....	....
3.0	0.32	0.29	0.22	0.15	0.12	0.09	....	....	....	....

	Rectangles—Lengths of Sides									
	1 × 1.5 Cm.	2 × 3 Cm.	4 × 6 Cm.	6 × 9 Cm.	8 × 12 Cm.	10 × 15 Cm.				
0.50	4.41	1.84	0.64	0.30	0.18	0.14	....	....	....	....
0.75	2.93	1.42	0.55	0.28	0.17	0.11	....	....	....	....
1.0	2.02	1.10	0.46	0.26	0.16	0.11	....	....	....	....
1.5	1.17	0.73	0.35	0.20	0.14	0.09	....	....	....	....
2.0	0.65	0.50	0.28	0.18	0.12	0.08	....	....	....	....
3.0	0.31	0.27	0.18	0.12	0.09	0.07	....	....	....	....

in millicurie-hours for various applicators having a filtration equivalent to two millimeters of brass has been developed.

Not all of these doses have been tested clinically, but they have been found correct at extremes of the range covered in the table.

It is of interest to note that according to these calculations in the case of the thinnest filter, 0.16 mm. brass, at first the intensity of radiation increases as we increase the distance of the applicator. This is due to the shape of the curve of Figure 3, which will be seen to be very steep for this thickness, so that a small increase in filter cuts down the radiation greatly. From Figure 2 it is evident that, for applications close to the skin, a decrease in distance increases the filtration for points near the sides of the applicator, and where the change in absorption is rapid this may counterbalance the effect of distance. For thicker filters, where the curve is not so steep, this does not occur. (This point has not yet been tested clinically.)

At the Memorial Hospital, where different types of gamma ray applicators are used for different conditions, the erythema dose has been determined clinically for each one. The following four applicators, each with filtration equal to 2 mm. of brass, are used.

TABLE III

D—*Applicators with filter of 2.0 mm. brass, and 2.4 mm. rubber*

Distance, Cm.	Point	*Tubes*—Length			*Circles*—Diameter					
		1 Cm.	2 Cm.	4 Cm.	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.
1.0	0.900	0.832	0.700	0.490	0.800	0.617	0.355	0.225	0.153	0.112
1.5	0.400	0.385	0.352	0.274	0.378	0.330	0.225	0.157	0.115	0.086
2.0	0.225	0.220	0.208	0.175	0.218	0.198	0.154	0.115	0.089	0.078
3.0	0.100	0.099	0.096	0.088	0.098	0.094	0.082	0.068	0.053	0.047
4.0	0.056	0.056	0.055	0.052	0.056	0.054	0.050	0.044	0.038	0.033
5.0	0.036	0.036	0.036	0.034	0.036	0.035	0.033	0.031	0.028	0.025
6.0	0.025	0.025	0.024	0.024	0.025	0.025	0.024	0.022	0.021	0.019
7.5	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.015	0.014	0.013
10.0	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.008	0.008

	Squares—Length of Sides									
	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.				
1.0	0.756	0.571	0.328	0.210	0.144	0.104	.....	.....	.....	.....
1.5	0.373	0.310	0.210	0.146	0.090	0.081	.....	.....	.....	.....
2.0	0.215	0.189	0.143	0.107	0.082	0.064	.....	.....	.....	.....
3.0	0.097	0.094	0.077	0.064	0.053	0.043	.....	.....	.....	.....
4.0	0.055	0.054	0.047	0.040	0.036	0.031	.....	.....	.....	.....
5.0	0.036	0.034	0.032	0.029	0.026	0.023	.....	.....	.....	.....
6.0	0.025	0.024	0.023	0.021	0.019	0.018	.....	.....	.....	.....
7.5	0.016	0.016	0.015	0.014	0.013	0.012	.....	.....	.....	.....
10.0	0.009	0.009	0.009	0.008	0.008	0.008	.....	.....	.....	.....

	Rectangles—Length of Sides									
	1 × 1.5 Cm.	2 × 3 Cm.	4 × 6 Cm.	6 × 9 Cm.	8 × 12 Cm.	10 × 15 Cm.				
1.0	0.728	0.497	0.255	0.148	0.098	0.070	.....	.....	.....	.....
1.5	0.360	0.287	0.172	0.113	0.078	0.056	.....	.....	.....	.....
2.0	0.212	0.182	0.112	0.087	0.064	0.048	.....	.....	.....	.....
3.0	0.097	0.090	0.072	0.055	0.043	0.035	.....	.....	.....	.....
4.0	0.055	0.053	0.045	0.038	0.031	0.026	.....	.....	.....	.....
5.0	0.036	0.034	0.031	0.027	0.023	0.020	.....	.....	.....	.....
6.0	0.025	0.024	0.023	0.020	0.018	0.016	.....	.....	.....	.....
7.5	0.016	0.016	0.015	0.014	0.013	0.012	.....	.....	.....	.....
10.0	0.009	0.009	0.009	0.008	0.008	0.008	.....	.....	.....	.....

NOTE.—It should be noted that in dividing up the applicators for purposes of computation, the outermost point considered was not at the edge but .05a farther in. Therefore, when taking the dimensions of an applicator for use with this table, the scale should extend slightly beyond the radium—one-twentieth of the whole width on each side.

TABLE IV

DOSE IN MILLICURIE-HOURS

Applicators having filtration equivalent to 2 mm. brass, and 2.4 mm. rubber

Distance, Cm.	*Tubes*—Length			*Circles*—Diameter				
	1 Cm.	2 Cm.	4 Cm.	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.
1.0	173	206	294	180	234	406	640	940	1,285
1.5	374	409	526	381	437	640	918	1,250	1,675
2.0	654	692	824	661	728	936	1,250	1,620	1,850
3.0	1,455	1,500	1,640	1,470	1,530	1,760	2,120	2,720	3,060
4.0	2,570	2,620	2,770	2,570	2,670	2,880	3,270	3,790	4,370
5.0	.....	4,000	4,240	4,000	4,120	4,370	4,650	5,150	5,760
6.0	.....	.....	6,000	.....	5,760	6,000	6,550	6,860	7,580
7.5	.....	.....	9,000	.....	9,000	9,000	9,600	10,300	11,000
10.0	.....	.....	16,000	.....	16,000	16,000	16,000	18,000	18,000

	Squares—Length of Sides					
	1 Cm.	2 Cm.	4 Cm.	6 Cm.	8 Cm.	10 Cm.
1.0	190	252	439	686	1,000	1,385
1.5	386	465	686	986	1,600	1,780
2.0	670	762	1,000	1,350	1,760	2,250
3.0	1,485	1,530	1,870	2,250	2,720	3,350
4.0	2,620	2,670	3,070	3,600	4,000	4,650
5.0	4,000	4,240	4,500	4,970	5,540	6,260
6.0	.....	6,000	6,260	6,860	7,580	8,000
7.5	.....	9,000	9,600	10,300	11,000	12,000
10.0	.....	16,000	16,000	18,000	18,000	18,000

	Rectangles—Length of Sides					
	1 × 1.5 Cm.	2 × 3 Cm.	4 × 6 Cm.	6 × 9 Cm.	8 × 12 Cm.	10 × 15 Cm.
1.0	198	290	565	974	1,470	2,060
1.5	400	502	838	1,275	1,845	2,675
2.0	679	792	1,285	1,655	2,250	3,000
3.0	1,485	1,600	2,000	2,620	3,350	4,120
4.0	2,620	2,720	3,200	3,790	4,650	5,540
5.0	4,000	4,240	4,650	5,340	6,260	7,200
6.0	.....	6,000	6,260	7,200	8,000	9,000
7.5	.....	9,000	9,600	10,300	11,100	12,000
10.0	.....	16,000	16,000	18,000	18,000	18,000

TABLE V

Applicator	Size, cm.	Distance of Application, cm.	Dose, mc.-hr.
"Pack"	8×12	6	9,000
"Pack"	8×12	10	20,000
"Block"	4×6	4	3,200
"Tray"	4×5	3	2,000
Tube	1.4	2	830

If these are to produce the same skin effect, the values of Table III for these applicators, multiplied by the dose in millicurie-hours,[4] in each case, should give the same result. We have

TABLE VI

Applicator	Factor	Dose	Product
Pack (1)	0.179	9,000	1,610
Pack (2)	0.077	20,000	1,540
Block	0.454	3,200	1,453
Tray	0.745	2,000	1,490
Tube	2.14	830	1,775

[4] The values in Table III are per millicurie-hour.

It will be seen that the agreement is as good as can be expected. The result for the tube is a little higher than the others, but the erythema produced in this case is more definite than for the other applicators. The erythema produced by the tube with the dose given is a faint but distinct reddening of the skin, appearing in about 24 hours. This fades away, to be followed in about two weeks by a deep cherry-red "secondary" reaction. This, in turn, fades, leaving a definite bronzing, which persists for several months. The doses specified for the other applicators do not, in general, produce a very definite reddening of the skin. A slight erythema may appear, and later a tanning, but even this is not always present. These doses for the applicators have been determined clinically by different physicians, and have been used in the hospital on many patients, so that the identity of their effects is firmly established. The slight discrepancy between the doses for these applicators taken from Table IV and the actual clinical doses is explained by the fact that Table IV is calculated from one well-known dose, the "Tray" of Table V, while the other clinical doses have been determined empirically. However, this discrepancy, from a practical point of view, is slight.

TABLE VII

INTENSITIES OF RADIATION AT POINTS UNDER EDGE OF APPLICATOR FOR SMALL DISTANCES

Filter Brass*	Distance	Int. Center	Int. Edge	Ratio
None	0.025a	1.52	0.78	1.95
	0.05	4.63	2.39	1.94
	0.10	12.2	6.52	1.87
	0.25	29.5	22.2	1.33
0.16 mm.	0.025a	0.164	0.082	2.00
	0.05	1.09	0.528	2.06
	0.10	3.30	1.48	2.23
	0.25	11.95	8.40	1.42
0.05 mm.	0.025a	0.528	0.266	1.98
	0.05	1.92	0.973	1.98
	0.10	5.43	2.79	1.95
	0.25	15.5	11.35	1.37
0.75 mm.	0.025a	0.894	0.432	2.06
	0.05	2.94	1.44	2.06
	0.10	8.27	4.31	1.92
	0.25	21.1	15.5	1.36
2.0 mm.	0.025a	1.147	0.552	2.08
	0.05	3.92	1.93	2.03
	0.10	11.6	5.72	2.03
	0.25	28.4	21.3	1.32

* With each thickness of brass is used the thickness of rubber indicated in Table I.

For applications close to the skin, the clinician is interested not only in the effect at the point under the center of the applicator, but in that under the edge, and at intermediate points. To obtain this for all the applicators would involve a large amount of additional computation. However, for the square it is fairly simple, and the results thus obtained offer an approximation for the other applicators. For the square, considering the effect at a point directly under the edge of the applicator, the method of attack was the same as previously outlined. Table VI shows, for different filters and small distances, the intensities of radiation at this point relative to those at the point under the center. These values correspond to those of Table I, and those for different filters are not comparable. It will be seen that, for distances up to one-tenth the side of the applicator, the point at the center receives twice as much as that at the side, and then the ratio begins to decrease; that is, the intensity of radiation at the side approaches that at the center, and this approach is quite rapid. This would indicate that, for distances greater than half the side of the applicator, the whole area under the applicator receives practically the same intensity of radiation.

When the application is to be made very close to the skin, and the whole area under the applicator is to receive a uniform radiation, it is better to express the dose in millicurie-hours per square centimeter. In this case the present work is not quite applicable. This method will be the subject of a future paper.

SUMMARY

1. A method is outlined for determining the intensity of radiation from any applicator, in terms of the intensity from a point source of the same strength.

2. General curves are given for tubular, circular, square, and rectangular applicators, for filters of 0.0, 0.16, 0.50, 0.75, and 2.0 mm. of brass.

3. Several examples are worked out to illustrate the uses of these curves.

4. A table is calculated, from the curves, for obtaining the intensities of radiation from about 100 definite applicators, at several definite distances, in terms of the intensity from a point source of the same strength at a distance of one centimeter.

5. Doses in millicurie-hours are given for applicators having a filtration equivalent to 2 mm. of brass and 2.4 mm. of rubber.

6. Doses for different applicators, clinically determined at the Memorial Hospital, are shown to check the calculations and curves of this paper.

In conclusion, the writer wishes to acknowledge her indebtedness to Mr. G. Failla, for his suggestion of the problem, and for his interest during the progress of the work; to Dr. Archie Dean, for his cooperation in determining the skin doses from which the curve of Figure 3 was plotted; and to Mr. James Sarros, for assistance in many of the computations.

PROTECTION TO THE OPERATOR FROM UNNECESSARY RADIUM RADIATION*

BY ALBERT SOILAND, M.D.

LOS ANGELES, CALIFORNIA

ONE of the most pernicious habits of the average radium worker is to fondle and play with the radium containers. If we would leave them severely alone, except when in actual preparation for a patient, and then handle them only with proper discretion and care, radium radiation would soon cease to be a source of danger to the operator. Unfortunately, habits are easily acquired, the bad more frequently than the good, and the cure is difficult, particularly in the case of the innocent-appearing little radium particles, whose potency for harm is so completely disguised.

Protective measures, to be efficient, must be painstakingly thorough, and they will naturally be subjective according to the physical type and amount of radium handled. In institutional work, where emanation apparatus is in service, the greatest caution must be exercised in relation to the larger radium body, and also the coexisting unscreened form in which the active agent appears. Most of the serious injuries which have appeared in operators to date have occurred in laboratories where large amounts of radium emanation are employed. Happily, this danger is so well recognized that stringent protective measures are generally enforced.

The object of these notes, therefore, is to call attention to the needs of the average radium worker, who imagines himself more or less secure from harm, because his radium element is already partially screened by metallic containers. That this is only false security, he realizes, when his fingers begin to show the characteristic trophic changes, and other constitutional disturbances become apparent, which are not accountable to other causative factors. It is to the increasing number of medical men who have qualified as radium workers, that these lines are addressed.

Adequate protection against unnecessary radium radiation is not at all difficult to obtain, and with a little care and common sense, it will soon become routine practice. The first thing to teach your operators is to maintain a respectful distance from all unscreened radiation. A few feet of air space is excellent. Next, instruct them to do all their work with long-handled forceps, and to work behind a suitable body screen, containing sufficient protective material to absorb all primary alpha, beta, and secondary beta radiation. In the writer's workroom, body screens are constructed with a curved face into which the body fits comfortably, enabling the operator to reach his radium applicators without undue muscular effort. A little practice soon accustoms the operator to the constant use of instruments, so

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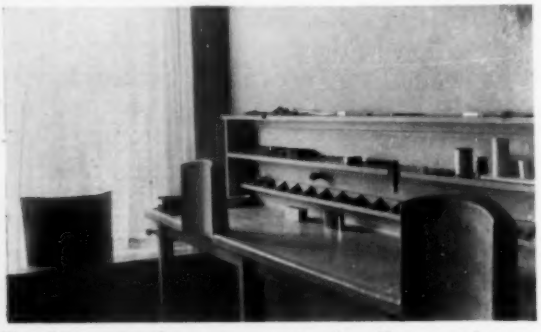
that bare fingers are no longer fashionable. It is even quite possible to become so proficient in the use of the forceps that the thread binding the package is readily tied with them.

With fairly large quantities of radium in daily use, it is, of course, necessary to reckon with the accumulated gamma radiation, and to combat its influence. It is the custom in most laboratories to alternate operators, arranging for one month in the radium room and one month at other duties. A tabulated blood-count record, made at stated intervals, of all exposed to radium radiation, serves as a guide to the working time permitted in the radium room.

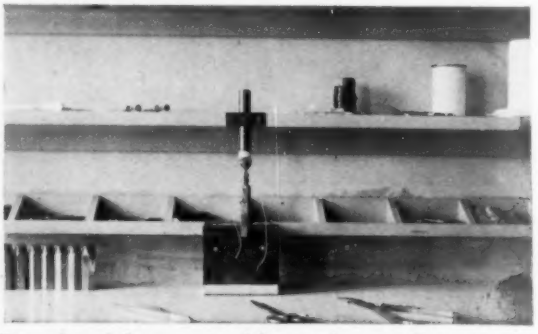


Showing general arrangement of radium workroom, with bench and shelving. Note protective curved body shields.

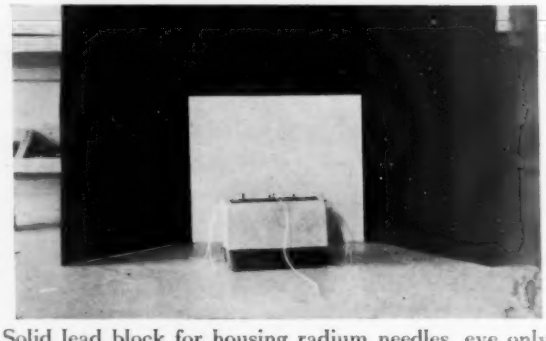
Extra large handled appliances for securing firm hold on radium tube or needle.

It is a good habit, in making up radium packages, to prepare all the accessories in advance, so that the actual time period of the radium contact may be as short as possible. On removing a package from a patient where adhesive plaster is used, the time element of contact can be materially lessened by dropping the mass into a cup of benzine. This quickly releases the adhesive strips, and permits of housing the radium contents quickly.

In handling radium needles, use a lead block in which the active part of the container is safely surrounded leaving only the eye exposed for threading. This is an excellent and simple procedure for taking care of this type of applicator. In handling radium tubes, we use small tunnels, adjusted to convenient brackets in the shelf, which feed the containers into whatever receptacle fits the case, finger cots being commonly employed. The same sort of arrangement is used for the surface plaques, which are finally mounted on a flat wooden stick or metallic handle. In both cases, it is found unnecessary to use the bare hands.



Tunnel and finger cot with attachments for preparing radium tubes, relieving fingers from contact with radium.



Solid lead block for housing radium needles, eye only protruding for threading.

Many dealers in radium are offering to the operators excellent protective devices, which have their various spheres of usefulness; and it is hoped that the day of unnecessary injury to radium workers is rapidly waning.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

Editor: H. M. IMBODEN, M.D.

Associate Editors: JAMES T. CASE, M.D. H. K. PANCOAST, M.D. J. S. SHEARER, PH.D.

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

DR. RUSSELL H. BOGGS: AN APPRECIATION

Dr. Russell H. Boggs, a charter member of the American Roentgen Ray Society, died suddenly at his home in Pittsburgh on the morning of June 2, 1922. He died of heart failure following a slight indisposition during which he had been confined to his house for about one week.

Dr. Boggs was born December 11, 1873, at Evans City, Pa. His family is one of the oldest in western Pennsylvania, having been here since 1763. His father was J. Walton Boggs; his mother, before her marriage, Sarah E. Johnston. He had several brothers and sisters, only two of whom reached adult life. His father died in 1896. His mother survives him.

He attended public schools in Allegheny and afterward attended the Pittsburgh Academy. He graduated in medicine from the Medical Department of the Western University of Pennsylvania in 1897. Following graduation, he opened an office in Allegheny and practiced general medicine for about a year. He then went abroad, where he became interested in dermatology and *x*-ray work. He studied at the St. Louis Hospital in Paris and at the University of Vienna, and it was there that he became interested in radiotherapy, which was later to become such an important part of his life's work. Returning to this country, he took a postgraduate course at the Skin and Cancer Hospital in New York City. He then came back to Pittsburgh and opened an office on Federal Street, Allegheny, where he installed *x*-ray equipment and began the practice of roentgenology. Two years later, he moved to the Empire Bldg. in Pittsburgh and retained offices in this building until he died. He was the first physician in Pittsburgh to make a specialty of roentgenology and to continue in that specialty. He began this work in the year 1900. His ability and enthusiasm soon gained him recognition in this new field, and we find him almost immediately a charter member in the American Roentgen Ray Society, the first large body of organized roentgenologists in this country. He was active in the Society from the first. Scarcely a year passed that he did not take part in the program. He was Secretary of the Society during the years 1904 and 1905, and Vice-President during the years 1905 and 1906. He was a regular attendant at all meetings, both annual and mid-year, and took an active interest in all the affairs of the Society.

Very early in his career, he became associated with the Allegheny General Hospital as roentgenologist. About the same time, he became Professor of Roentgenology in the Dental Department of the Western University of Pennsylvania, and was also Professor of Roentgenology in the Medical Department of the same institution in conjunction with Dr. Geo. C. Johnston of Pittsburgh. He held these positions with the Western University of Pennsylvania until it became merged into the University of Pittsburgh in 1908. He was also roentgenologist to St. Francis Hospital, Columbia Hospital and Pittsburgh Hospital, and consulting roentgenologist to Mercy Hospital. In his later years, he resigned from these hospitals one at a time until, at his death, he was connected actively only with the Pittsburgh Hospital. He was on the Staff of the Columbia Hospital as dermatologist and on the Staff of the Suburban Hospital in Bellevue, Pa. as consulting roentgenologist. At one time,

he was also connected with the Sewickley Hospital.

Dr. Boggs was married first in 1899, to Blanche S. McCready of Allegheny, Pa. Mrs. Boggs died in the year 1910. He was married the second time to Etta A. Houck of Braddock, Pa., who survives him. He had no children.

He was always a voluminous writer, and appeared often before all the medical societies of which he was a member. How he ever found time to write so extensively, to do the *x*-ray work at his numerous hospitals, and to attend to a large private practice, was always a source of wonderment to his friends. The secret lay in his remarkable energy and ability to work long hours after the ordinary individual would be too fatigued to accomplish anything. His earlier work in roentgenology, like that of almost everyone else at that period, was devoted largely to the development of technique. He was one of the few roentgenologists in the country, however, who took much active interest in radiotherapy at this time. His diagnostic work was always of a superior quality, but as time went on, he became more and more interested in the therapeutic branch of his work. As soon as *x*-ray machines reached a stage of development where they could be depended upon to give uniform results, and after the invention of the Coolidge tube, he gave most of his attention to therapy, and it was after this time that his most brilliant work was done. In 1914 he began to use radium, and although he went into this work conservatively, he soon became enthusiastic and gave much of his energy to it. At the time of his death, he was one of the most expert users and one of the largest individual owners of radium in this country.

A perusal of his published writings impresses one in many ways, but I think most of all, it arouses admiration for his optimism. His enthusiasm for his work as the years went by, in the face of the disappointments which must have come to him as they come to all of us, always aroused in me great admiration. He was always enthusiastic about the work he was doing, or the work he was about to do. He had an unshaken faith in the value of radiotherapy, and in spite of all the fads and fancies which naturally come and go with the development of any science, he always stuck to his main purpose, which was the treatment of malignant disease. He held very strong views on certain points in regard to the treatment of malignancy, and seldom lost an opportunity to emphasize them in his writings, or in discussion. A few of them are mentioned here.

He believed that the treatment of malignancy should be a specialty, and that one following it should be competent to carry out any line of treatment that might be indicated in the individual case. He deplored the fact that non-medical persons were allowed to give *x*-ray treatments in medical institutions. For that matter, he was always opposed to non-medical persons doing radiographic work; and to the best of my knowledge, never employed a technician for this purpose, but had medical assistants. One of his most admirable qualities was his attitude toward young roentgenologists. He always encouraged them and did everything in his power to help them along. He took every opportunity to emphasize that incomplete operation of malignancy was worse than useless, as it always hastened metastasis and death; and that the removal of the center of a carcinomatous mass never retarded the disease, as there was a growing edge often far from the center of the lesion which was unaffected, or perhaps even had a better chance to grow after such operation. He held that the removal of adjacent lymphatic glands took away nature's barrier against invasion and did more harm than good. He had the same views about tuberculous glands. He thought that malignancy was always regional and not local when it was discovered. For that reason, the statement so often made that every cancer is curable at some stage by operation was misleading because, as a matter of fact, it was seldom or never discovered at that stage. Because cancer is a regional disease, it is useless to treat the local lesion without raying the lymphatics also. He took every occasion to emphasize the importance of raying the lymphatics of the chest in breast cancer,

of the neck in cancer of the lip, and of the pelvis in cancer of the uterus. He usually used radium over the primary lesion and roentgen rays over the lymphatic distribution. He was one of the first to advocate ante-operative radiation in cancer of the breast, and he adhered to this consistently throughout his career. The last work in which he appeared to be most intensely interested was the imbedding of radium needles into the breast in inoperable cases of cancer, with radiation of the neighboring lymphatics, in the hope of making these cases operable. In his last papers he ventured the opinion that in time to come, all such cases would be so treated before operation.

In spite of the fact that he practiced roentgenology for nearly twenty-five years, and handled large quantities of radium for eight years, he never developed any serious burns. Although he had a few keratoses on his hands and some brittleness of nails, he never had any serious trouble, and could probably have practiced his specialty without hindrance from that cause for a long time to come. Probably his unusual freedom from burns was due to the fact that he never used the fluoroscope very much.

Dr. Boggs was a member of the County and State Societies, American Medical Association, Pittsburgh Academy of Medicine, American College of Physicians, The Roentgen Ray Society of Central Pennsylvania, American Roentgen Ray Society, The Radiological Society of North America and the American Radium Society. In the World War, he served as Lieutenant in the U. S. Navy.

He was a faithful attendant at the local medical societies, as well as the special societies. He was always seen at the meetings of the various Roentgen Societies and the Radium Society, and always took an active part in the program. He was interested in every new discovery and improvement in technique or apparatus, and was always among the first to adopt new ideas. One can easily see that he possessed a truly scientific mind; and this, together with his remarkable energy and enthusiasm, made of him a man of rare ability.

His wide experience will be sadly missed in the new era of radiotherapy upon which we are now entering.

A partial list of Doctor Boggs' articles is appended:

X-ray diagnosis of calculus. *Tr. Am. Roentg. Ray Soc.*, 1902.

Carcinosis of bone secondary to a growth in some epithelial organ. *N. York M. J.*, Dec. 2, 1911.

Roentgenological study of the alimentary canal. Read, Allegheny County Medical Society, 1914.

Progress made in radium and *x*-ray therapy. Read, Ohio Valley Academy of Medicine, Sept. 3, 1914.

Radium and mesothorium in conjunction with roentgen therapy. Read, American Roentgen Ray Society, Sept. 10, 1914. *N. York M. J.*, Dec. 12, 1914.

Value of radium, supplemented by cross-fire roentgen rays in treatment of malignancy. Read, Allegheny County Medical Society, Jan. 19, 1915.

Radium and mesothorium in conjunction with roentgen therapy. Am. J. Roentgenol., April, 1915.

The treatment of epithelioma by modern radiation. *N. York M. J.*, July 3, 1915. Read, Clearfield, Jefferson & Elk County Med. Soc., June 10, 1915.

The local application of radium supplemented by roentgen therapy. American Roentgen Ray Society, Atlantic City, Sept. 24, 1915.

The local application of radium supplemented by roentgen therapy. Am. J. Roentgenol., Feb., 1916.

The local application of radium supplemented by roentgen therapy. *Surg., Gynec. & Obst.*, March, 1916.

The treatment of tuberculous adenitis by roentgen rays. *N. York M. J.*, May 27, 1916. Read, Pittsburgh Academy of Medicine, Feb. 29, 1916.

The treatment of epithelioma of the lower lip. *Interstate M. J.*, 1916, xxiii, No. 5.

Treatment of leukoplakia by radium. *Texas M. J.*, Nov., 1916.

Differential roentgen diagnosis in bone diseases. *N. York M. J.*, Jan. 20, 1917.

Carcinoma of the uterus treated by a combination of radium and roentgen rays. Read, American Roentgen Ray Society, Sept. 20, 1916. Am. J. Roentgenol., May, 1917.

The treatment of malignancy by radium. *Med. & Surg.*, June, 1917.

Value of roentgen rays in diagnosis of carcinoma of the stomach. *N. York M. J.*, Aug. 25, 1917. Read, Roentgen Ray Society of Central Pa., May 26, 1917.

The treatment of epithelioma by radium. *Internat. Clin.*, 1917.

The treatment of acne by the roentgen rays. *Urol. & Cutan. Rev.*, Feb. 18, 1918.

Treatment of epithelioma of the lower lip by radium. *Urol. & Cutan. Rev.*, Feb. 18, 1918.

The treatment of carcinoma of the breast by the roentgen rays. *Interstate M. J.*, March, 1918.

The value and limitation of radiotherapy in internal medicine. *Med. Fortnightly & Lab. News*, March, 1918.

The comparative value of radium and roentgen radiation. *Penn. J. Roentgenol.*, May, 1918.

Post-roentgen treatment of carcinoma of the breast. Am. J. Roentgenol., June, 1918.

Radiation in the treatment of uterine fibroids. *Med. Council*, Dec., 1918.

Complications of influenza from the roentgenological standpoint. *Bull. Allegheny Co. Med. Soc.*, March 1, 1919.

The treatment of epithelioma by radium. *Am. J. M. Sc.*, July, 1919.
Treatment of goiter by radiation. Am J. Roentgenol., Dec., 1919.
Radium in the treatment of carcinoma of the cervix and uterus. Eastern Section, Amer. Roent. Ray Society, Jan. 31, 1920.
Incompetent radium and roentgen treatment in malignancy. *Urol. & Cutan. Rev.*, Feb., 1920.
The value and limitations of radium and the roentgen rays in the treatment of disease. *Med. Council*, May, 1920.
The lethal dose of radium in malignancy. *N. York M. J.*, June 12, 1920.
Lethal and erythema dosage of radium in malignancy. Am. J. Roentgenol., Aug., 1920.
The treatment of carcinoma of the breast by imbedding radium supplemented by *x*-ray. Am. J. Roentgenol., Jan., 1921.
Treatment of malignant growths of the mouth and throat by radium supplemented by other methods. *J. Radiol.*, Jan., 1921.
Radium treatment of mouth and throat. *Penn. M. J.*, Dec., 1921.
Radium and deep therapy in the treatment of malignancy. *Radium*, Jan. and Feb., 1922.

In addition, the following articles have been written and published, but we are unable to secure the dates and the names of the journals in which they appeared:

Treatment of non-malignant diseases by the roentgen ray.
Physiological actions and therapeutic uses of roentgen rays.
The treatment of multiple glandular tumors.
Roentgen therapy in dermatology.
Review of roentgenology.
The treatment of malignancy in the mouth and throat.
X-ray as a means of diagnosis and therapeutic agent with report of a case.
The uses of *x*-ray in medicine and surgery.
Lethal and erythema dosage.
Protection of patient during roentgen exposure.
Treatment of cervical tuberculous lymphadenitis and tuberculous dermatosis by means of the *x*-ray.
The value of the roentgen rays in thoracic lesions.
The value of imbedding radium in addition to surface application of radium and *x*-ray in treatment of carcinoma of the breast.
Remarks on ichthyosis.
The technique of calculus diagnosis.
Tuberculous lesion illustrated by the roentgen rays.
Tuberculous adenitis and its treatment by radiotherapy.
The modern trend in the treatment of malignancy.
The value and limitation of radium in the treatment of cancer.
X-ray interpretation.
X-ray as a means of diagnosis and as a therapeutic agent, report of cases.
The radiographical examination of the gastro-intestinal tract.
Influenza.
Fibroids.
Comparative value of radium and roentgen radiation.
Differential diagnosis in bone disease.
Radium in the treatment of carcinoma of cervix and uterus.
The treatment of carcinoma of the cervix and uterus by radium supplemented by deep roentgen therapy.
The treatment of tuberculous adenitis by roentgen rays and radium.
Imbedding of radium throughout different parts of the body in malignancy.
Treatment of glandular metastases of carcinoma.
The lethal dose of radium in malignancy.
The treatment of tuberculous adenitis by roentgen rays and radium.
A comparative study of fractures of the extremities.

G. W. Grier.

THE LEONARD PRIZE

The American Roentgen Ray Society is again offering the Leonard Prize in 1923, details for which appear on advertising page ix of this number of the Journal. The manuscripts submitted for the 1921 prize were of a high order of merit and covered a variety of subjects pertinent to roentgenology. It is to be hoped that the contestants for the next prize will be equally zealous in their efforts.

A CHANGE IN THE NAME OF THE JOURNAL

At the last annual meeting of the American Roentgen Ray Society held at Los Angeles, California, the Executive Council unanimously decided to change the name of the Journal so as to read "The American Journal of Roentgenology and Radium Therapy." This step was thought advisable in view of the increasing prominence of radium therapy and the fact that the American Radium Society has made this Journal its official organ. This change will take effect in an early number.

Subscribers to The American Journal of Roentgenology *visiting New York City, are invited to make the office of* The Journal (*69 East 59th Street, New York*) *their headquarters. Mail, packages or baggage may be addressed in our care. Hotel reservations will gladly be made for those advising us in advance; in this case, kindly notify us in detail as to requirements and prices. List of operations in New York hospitals on file in our office daily.*

TRANSLATIONS & ABSTRACTS

DELHERM and THOYER-ROJAT (Paris). Radiologic Study of the Great Vessels of the Base of the Heart. (*Gaz. d. bôp.*, May 21, 1921, xciv, 40.)

The work of the authors was performed on the cadavers of relatively young subjects, free from thoracic deformities and disease of the circulatory apparatus. The vessels of the base were first injected, for the details of which the reader is referred to Thoyer-Rojat's monograph (1919). As a result of the studies in question the authors are able to affirm that the shadow of the ascending aorta slightly overlaps the sternum to the right, and is doubled to the left by the shadow of the initial descending aorta. The pulmonary artery projects cleanly to the left of the origin of the aorta, while the left superior cava appears a little to the rear and cleanly to the right of the ascending aorta, overlapping the sternum broadly. These appearances all pertain to the frontal position; if now the cadaver is rotated 20 to 30 degrees into the right oblique position, the shadow of the ascending aorta and that of the initial descending aorta are superposed, giving the impression of the classic "glove finger." At the same time the pulmonary aorta tends to disappear behind the aorta, while up to 30 degrees of rotation the cava is projected to the left of the "glove finger" upon the vertebral column. If rotation is to 40 degrees the two aortic shadows are dissociated, the ascending passing to the right and the descending to the left of the observer, the pulmonary still behind the aorta, while the cava superior, conjointly with the ascending aorta, crosses the shadow of the descending. When rotation is carried to 50 degrees the two aortic shadows are separated, the shadow of the descending being nearly in contact with the vertebral column: the angle formed by the two branches of the aorta is quite acute. If now the cadaver is placed in the left oblique position at 30 degrees' rotation, the three portions of the aorta are cleanly dissociated, forming a figure 8; the pulmonary artery projects into the latter, while the cava superior shadow is confused with that of the descending aorta behind which it is projected.

What do these findings signify in the examination of the living? In the normal subject the descending aorta and the other large vessels escape investigation. If we wish, for example, to determine the caliber of the aorta, a special device, the beginnings of which go back to 1912, may be invoked. A framework for the support of the patient is mounted on a turntable, the axis of rotation corresponding to the posterior mediastinum. In the frontal position of the standing patient the visibility of the aorta is low, because it is so largely masked by bone shadows. Nevertheless this very absence of definition is of diagnostic value because it indicates a normal vessel. To obtain a correct idea of diameters it is necessary to use the oblique positions. Rotated 30 degrees to the right anterior oblique position, the vertebral shadow tends to dissociate itself from the cardiac shadow, the latter traveling to the observer's right and the former to his left. At 30 degrees a thin thread of light appears between the aortic shadow and the vertebral column, corresponding to the posterior mediastinum. The aortic image is now easily read. This is the optimum position, as further rotation will introduce new elements. The caliber may now be obtained by orthodiagraphic methods. As a check on the measurements the subject may now be rotated to the left anterior oblique position at an angle of from 30 to 40 degrees. The authors mention only the ascending aorta in this connection. This position is the one adapted to mensuration of the pulmonary artery. The article concludes with remarks on aortitis, aortic aneurysms and pathological states of the pulmonalis and cava, which are of sufficient interest for a separate study.

BOWER, JOHN O. Operating Cystoscope in Application of Radium to Cancer of the Rectum, following Colostomy. (*Surg., Gynecol. & Obst.*, April, 1922.)

The writer reports 3 cases of cancer of the rectum in which an operating cystoscope and a specially devised applicator were used to implant radium in the proximal portion of the growth.

Crossfire was obtained by inserting radium properly screened against the growth through the anus, by means of the following technique:

(*a*) Lower left rectus or inguinal colostomy under spinal anesthesia, the bowel being opened on the third or fourth day by thermocautery.

(*b*) On the seventh or eighth day the lower segment is flushed through a 25 F. catheter; when the fluid returns clear the cystoscope with irrigating tube attached is inserted, the obturator withdrawn, the telescope inserted and the special instrument holding the radium needle is introduced into the cystoscope. The radium needle with silk cord attached is

imbedded in the growth. This is repeated until as many needles as required have been introduced. The free ends of the cord are secured by hemostat or fastened by adhesive to the patient's skin.

(*c*) Radium, properly screened, is inserted against the lower portion of the growth through the anus, using a rubber applicator.

The advantage of the method is maximum radiation due to accurate placing.

A. C. C.

BURROWS, ARTHUR and MORRISON, J. M. WOODBURN. The Treatment of Exophthalmic Goiter by Radiations. (*Proc. Roy. M. & Chir. Soc.*, Section on Electro-Therapy, July, 1920, xiii, 132.)

The effects of *x*-rays and radium are considered by the authors, identical, and the difference in the usage of the two is taken up later.

They regard exophthalmic goiter as a well defined disease in which hyperthyroidism is definite, persistent and pathological by the time the case reaches the roentgen therapist. The cases are classified into three general types, namely, severe, medium and mild. Etiologically, three types are distinguished: (1) Cases which are pathological continuations of a physiological process such as pathological conditions following pregnancy and child-birth (these may overlap the next two classes); (2) cases following shock, which initiated the disease through the sympathetic nervous system; (3) the infective group, following pneumonia, influenza, fevers, pyorrhoea, etc. When treating any case of exophthalmic goiter by radiation of the thyroid, the writers believe it necessary to eliminate sources of chronic infection, diminish or mitigate the direct effect of shock, and, so far as possible, provide for natural mental and physical rest.

Their technique is given in detail. An endeavor is made to dose the whole of the gland and any accessory substernal thyroid at each treatment. This includes the thymus and the cervical sympathetics, but more reliance is placed on the thorough radiation of the thyroid than on these accessory areas. With the patient in the supine position, the head and shoulders slightly raised, and the head turned to one side, the whole of one lobe and a portion of the isthmus is exposed to a measured, filtered dose. Then the opposite lobe and portion of the isthmus is likewise exposed. A ten in. target skin distance is used with an oval-shaped extension tube which completely covers the lobe, reaching from just below the clavicle to a little above the upper pole of the gland, being directed upwards and inwards. Each lobe and isthmus receives an equal amount, the isthmus receiving half the amount given each lobe. The dose given each side, measured by Hampson's radiometer, after filtration, is 3H. With an alternative spark gap of 6 or 7 in. and the milliameter registering 3 ma., the time taken is from 9 to 10 minutes. The filters used are from 1 to 3 mm. of aluminum and three layers of felt. The majority of the cases from which statistics are taken received two treatments a week for three or four weeks, then one treatment a week. As the case progresses the intervals are extended first to fourteen days, then to twenty-one, then twenty-eight days, two months, three, and finally six months. When patients partially relapse, the intervals are shortened until satisfactory progress is obtained. The dosage given is approximately the same on each occasion. The cases are kept under observation after the disappearance of the symptoms so that a relapse may be detected and treated early. Most of the cases from which statistics are given have been under observation for from two to five years.

With radium, the great majority of the cases were irradiated by applying plates of the element or emanation to the skin over the enlarged gland. Plates of a strength of 2.5 mg. of the element, or 2.5 mc. of the emanation, to the sq. cm. are considered the best. The size and number used varies with the degree of severity of the case and the size of the thyroid gland. For a mild or ordinary case, 30 to 50 mg. are considered sufficient, but this is frequently increased, when necessary, to twice the amount. The plates are screened by 1.5 to 2 mm. of lead, and secondary radiation is effectually stopped by 24 to 36 layers of black photographic paper. Silver, aluminum, gold or platinum of the requisite thickness could be used as well as lead. Each piece of apparatus is inclosed in good rubber sheeting, and a piece of lint or wool may be put over the paper before the apparatus is made up, to make it more comfortable. Exposures of twenty-four hours are given every six weeks, the apparatus being fixed to the skin by adhesive strapping and bandages. The heavy treatments at long intervals are preferred. Caution is urged. The skin must be watched closely and should any reddening occur, treatment should be postponed

The writers look upon exophthalmic goiter as an example of vicious circle in disease. Ray treatment to one cycle, the thyroid, removes one link from the circle, without disturbing the nervous factor, for good or ill. They concede that widespread irradiation including the anterior aspect of the neck and

upper chest often seem to give better results than the more local application, but they believe that this is due more to the greater dose received by the thyroid than to any action on the thymus or cervical ganglion.

In their experience, the immediate effect of radiation seems to be an inhibition of the secretory function of the gland. The lowered pulse-rate will rise again after an interval if no further treatment is given. Prolonged treatment sets up a more permanent fibrotic process. Removal of the thyroid factor in bad cases may leave behind ameliorated, but still severe, nervous symptoms, such as palpitation, exophthalmus, indigestion and rarely diarrhea. The symptoms usually abate a great deal, however, as time goes on. It is in connection with these cases that the interval of complete stoppage of both *x*-ray and radium treatment is so useful. Too vigorous a rest and dietetic treatment should be avoided because of the depressing effect on the patient. Rather, they should return as nearly as possible, during that interval, to normal life.

The first sign of improvement is a feeling of well-being, and it is usually observed by the end of the third week. The pulse-rate, as a rule, after a quick drop, is followed by a slight rise and gradually gets slower, as low as sixty per minute. The writers state that they have never seen a case of artificially produced myxedema after even the most prolonged and severe treatment. To their minds, should it occur, it would be but a proof of the efficacy of the rays in the treatment of hyperthyroidism. Some slight quickness in the pulse rate may remain. The increase in the weight of the patient is, to them, the best indication of good progress toward recovery.

During recovery no particular symptom or sign goes first, but all gradually diminish except that the exophthalmus is the last to go, and may remain in a patient virtually cured. If the thyroid enlargement is not of long standing it steadily grows smaller under treatment and after. Intercurrent disease and foci of infection delay the favorable progress of the case. They must be removed. The blood picture is of no help in determining the progress of the case.

Prognosis is difficult. Very severe cases are often spectacular in progress, but the end results are not so good as in the mild ones. The most difficult to treat are those in which the exophthalmic type has developed in a case of old simple goiter. In these the treatment is prolonged, the progress slow. The acute toxic cases are considered hopeless by the writers, and they believe that such cases should not be treated by radiation. Only one death is reported (under the heading "not improved" in the radium column).

The results are given in table form, "perfect" meaning no symptoms or signs remaining; "good functional," that the patient can follow an ordinary, not too arduous life; "improved," that the patient is undoubtedly better than when treatment was begun; "abandoned treatment" includes those cases in the service and those who moved away. The tables are for a series of 100 consecutive cases treated with *x*-rays, and the first 100 cases treated by the authors with radium.

	X-Rays	*Radium*
Perfect	27	20
Good functional	49	20
Improved	20	40
Abandoned treatment, not improved	4	20

In summarizing, the writers discuss the advantages and disadvantages of the medical and surgical treatment of exophthalmic goiter and conclude by saying that they do not think there is evidence that any treatment of exophthalmic goiter gives such safe, uniform and promising results as irradiation of the thyroid gland. KARL F. KESMODEL.

HALPHEN AND COTTENOT (Paris). Clinical Cure of a Spinocellular Cancer of the Larynx by Roentgenotherapy. (*Rev. de. laringol.*, etc., Nov. 1, 1921.)

Despite the short interval since treatment the result in this case is so clean-cut that the authors feel obliged to publish it. The diagnosis made by biopsy is beyond doubt.

Patient, a man of fifty-eight, seen Nov. 30, 1920; had complained of his larynx for two months. The symptoms were local, the general condition being good and unimpaired. The mirror showed a papillary, mulberry-like growth on the lingual face of the epiglottis, which somewhat obstructed the view of the cords. There was a second lesion of the same nature midway in the right cord. A piece was taken from the epiglottic lesion for biopsy and the pathologist reported spinocellular epithelioma. The regional lymph-nodes showed no enlargement.

Preliminary tracheotomy was performed Dec. 30th. Total laryngectomy and radium had been deferred until the *x*-rays could be given a test, which was begun ten days after tracheotomy. From Jan. 11th to the 17th six daily applications were made of very penetrating rays equal to 20 cm. spark, filtration 8 mm. aluminum. Rays were applied on both lateral aspects at the level of the thyroid plates. The total dose for the six sessions was 44H. There

was a slight external reaction, but nothing within the larynx. The improvement was so striking that in ten days it was hardly possible to recognize the epiglottic growth. The lesion on the cord, however, was still visible, so that 6 more daily sessions were given, from Feb. 9th to the 15th. The administration and dosage were the same, and eight days after the last session the entire larynx was quite clean. There was no sign of any recurrence on March 18th, but two extra sessions were given prior to extracting the tracheotomy tube. The total given was 15H. The tube was extracted April 5th.

Since this period the patient, although not apparently affected in weight by his disease, has put on 12 pounds and continues free from local trouble.

The result is the more remarkable because spinocellular cancers are naturally malignant and radioresistant. He was last seen July 10, 1920, and nothing has been heard from him since. His home is in Constantinople.

An important question is "Was the preliminary tracheotomy necessary?" The author replies "Yes," and for two reasons. First, the larynx is put at functional rest; second, the use of penetrating rays is likely to cause some edema of the larynx. This did not develop in the present case; nevertheless the author would do the same thing again under the circumstances.

STEIGER (BERNE). Pregnancy and Labor after Radiation of a Myomatous Uterus. (*Schweiz. med. Wchnschr.* Nov., 24, 1921.)

The patient was thirty-nine, had borne four children before 1907, and then had no conceptions until 1914, when she had an abortion in the tenth week. She entered the clinic June 1917 with a fibroid uterus. She also had exophthalmic goiter (a condition believed to favor sterility). She was rayed 3 times—June 7th, June 21st and July 5th. The tumor was now seen to be smaller. She was given a second series of two sessions between July 19th and Aug. 2nd. Tumor now notably smaller. Menstruation July 19th and July 28th each lasting three days.

Seen again the following November (1917). Amenorrhea since September 22nd. Goiter worse, and the thyroid was treated with the rays until May, 1918. This condition was notably improved. She had received some *x*-ray treatment of her neck before consulting for fibroid.

Next seen October 8, 1919; believed herself pregnant. Seen January 14, 1920. Fetal heart spunds heard. Confined April 20th. Infant born at term. Unable to nurse it. Child strong, well formed. Menstruation resumed. Fibroid size of fist. Goitre became aggravated during pregnancy. This case shows that despite radiation of the ovaries (of a woman not likely, from her clinical history to conceive) conception took place and gestation went to full term, the child being free from malformation. The author theorizes at great length.

PINCHERLE. Radiography of Tumors of the Left Hypochondrium. (*La Radiol. Med.* July, 1921.)

In all cases in which ordinary resources are insufficient for diagnosis in suspected tumors in this region, the *x*-rays may be invoked. Neoplasms may of course originate in the spleen, stomach, intestine, left kidney, pancreas, retroperitoneal glands, mesentery, etc. A condition confounded with tumors is subphernic abscess, and in the female, tumors in the left hypochondrium may originate in the genital apparatus.

The indirect radiological examination, based on the relation of the neoplasm to the viscera of this region, is often of great service. The spleen is but little accessible to a direct examination, although when enlarged it is the more readily visible, giving then an ovoid shadow, homogeneous and smoky, not well outlined against the surrounding structures. It often happens in the indirect examination that the gas bubble of the stomach is shifted toward the middle line, while not affected in respect to its relation with the vault of the diaphragm. Much advantage accrues from artificial pneumoperitoneum.

Pincherle's technique in the examination of the digestive apparatus in suspected tumor of the left hypochondrium is as follows: On the evening preceding the examination a saline purge is given, and on the morning following, an enema. The patient fasts up to the time of examination, when he is placed supine on the trochoscope and is given an enema of 300 gm. of gelatinized barium in 800 gm. of water. He is then examined in the erect position from the side.

In regard to pancreas tumors, several Italian radiologists have recently published reports. In these cases, diagnosis is based on the behavior of the stomach, which is, however, equivocal, because in addition to its own variability there should be reckoned the alterations due to the presence of the tumor. The most important datum is the displacement of the stomach, which may, according to the case, be to the right or left.

There are numerous records which show that tumors of the spleen and left kidney may produce a depression of the left flexure of the colon from its habitual subdiaphragmatic position.

This depressed flexure then stands behind the lower pole of a splenic tumor, while if the neoplasm is of renal origin it stands above and is often displaced mesially. In renal tumor with marked ptosis the neoplasm may be seen in a space bounded above by the transverse colon and externally by the descending colon.

Subphrenic abscesses are usually displaced below the splenic flexure, while indirect radioscopy shows that the gas bubble in the stomach is depressed, compressed and at times displaced mesially. Tumors of the pancreas do not usually modify the left flexure, but may compress and displace the stomach. The left half of the diaphragm is often elevated, while often tumors of the left hypochondrium and especially subphrenic abscesses interfere with the play of this structure.

Wissing, Ove (Copenhagen). Comparative Researches upon the Motility of the Stomach. (*Acta Radiol.*, 1922, i, Fasc. 3, 243–261.)

The majority of normal stomachs empty within two or three hours after the opaque meal is digested, and in the majority of cases the barium gruel passes through the stomach somewhat more rapidly than the bismuth gruel.

There appear to be certain stomachs, normal in other respects, which possess an astonishingly irregular motility.

The motility of the stomach has been examined in 217 patients suffering from various complaints of the digestive canal; the examinations were made either six hours after Kemp's test-meal, or five hours after the ingestion of barium gruel (with 150 gm. of sulphate of barium). A retention of the barium after five hours ought probably to be considered as a manifestation of a motor incompetency, and for this reason the author recommends making the radiological examinations of the motility five hours (and not six) post coenam.

The radiological test cannot be entirely substituted for the clinical method, but the two tests can complement each other, for, by employing both, an increase in the duration of the evacuation is found more often than when one of these methods is used.

A retention of the barium for twenty-four hours (pseudo-retention) may exist without there being any ulcerous or cicatricial changes at the level of the pylorus; thus, for instance, in atony, and when ulcers are in the body of the stomach.

In gastric ptosis, neither the low position of the stomach nor an atonic condition of the organ, nor both these factors combined, appear to have a cardinal influence on the duration of evacuation.

Eiken, Th. (Copenhagen). Clinical Examinations of a Four Hours' Roentgen Retention. (*Acta Radiol.* 1922, i, Fasc. 3, 262–265.)

On comparing the different groups, it may be said, as a general rule, that the further away the disease is removed from the stomach, the less is the influence on its emptying capacity.

As a result of the examinations the author ventures to say that, in a four hours' roentgen retention we have a delicate test of the emptying capacity of the stomach, a test which, however, must always be judged in association with the other clinical findings.

P. Fleming, Möller (Copenhagen). Roentgen Examination of Ileocecal Tuberculosis with Special Reference to the So-called Stierlin Sign. (*Acta Radio.* 1922, i, Fasc. 3, 266–273.)

The so-called "Stierlin Sign" in ileocecal tuberculosis has not the great diagnostic value which Stierlin has ascribed to it. It is certainly a relative rarity.

The roentgen-ray picture of ileocecal tuberculosis, and the other tumor-producing complaints in the ileocecal region, commonly corresponds to the well-known picture of other tumor formations in the digestive tract, and has as diagnostical signmarks:

1. A pathological diminution of the shadow of the caecum-ascendens;
2. An abnormal shape and contour in analogy with the shadow defects in cancer ventriculi;
3. An inexpansibility and stiffness of the intestine wall.

Åke, Åkerlund (Stockholm). The Niche Symptom in Carcinoma Ventriculi. (*Acta Radiol.*, 1922, i, Fasc. 3, 274–283.)

The internal treatment of niche-formed gastric ulcers, which is being ever more and more employed, brings increased responsibility in its train for the roentgenologist in the interpretation of verified gastric niches.

According to a report on the rather sparse roentgen-ray literature appertaining hereto, over 7 cases of niche-formed, carcinomatous gastric ulcers are recorded, which have come under observation during the period of a few years. In 3 of these cases the correct diagnosis was made at the first roentgenological examination; in a further 2 it was expressly stated that carcinoma could not be precluded.

It can happen that the determination of acidity in niche-formed, cancerous ulcers gives normal values. The presence of niches in older persons, hitherto healthy, is to be interpreted as a serious warning; atypical niche localization is also suspicious of carcinoma.

The tracing of a hard, stiff, wall- or plateau-like infiltration in the neighborhood of the niche—which infiltration can now and again appear more distinctly on the plates that have been taken from direct compression—strengthens one in this suspicion. In uncertain cases a speedy control-examination should not be neglected.

KREUXFUCHS, S. & SCHUMACHER, O. (Wien). The Topographical Conditions of the Interlobular Fissures of the Lungs. (*Acta Radiol.*, 1922, i, Fasc. 3, 284–307.)

If we summarize the most important experiences from our investigation, we arrive at the following:

The median interlobar fissure is triangular in shape, with dorsal, short base and ventral apex. The anterior and lateral surface is steep and curved convexly.

The lateral border or the median interlobar incisure (fissure-inlet) is frequently adherent medially, descending forwards. It presents the form of a recumbent *S*, but is also curved in conformity with the thoracic curve.

The posterior border or section-line with the principal fissure represents the cut of the middle lobe wedge and lies transversely in the transverse section of the body. But this line is often not to be seen on the floor of the fissure, as parenchymatic or pleural bridges extend from the posterior lobe to the middle lobe.

The medial border forms the pleural sac from the superior lobe to the middle lobe. It always lies in a sagittal direction, and can reach to the medial anterior border of the lung.

The fissure is so located in respect to the hilus that its most posterior and medial point lies exactly opposite to the so-called depth of the fissure, hence the "hilus-near point." The level of the fissure is between the hilus-centre and the lower margin of the hilus.

The principal fissures show right and left differences in regard to the direction of their course, the curve of their surfaces, the height of their dorsal portions and the section-line of the base of the lung; both are approximately oblong and surround the hilus at the medially located pleural sac; their surfaces are therefore approximately kidney-shaped. The left one extends higher up, the highest dorsal point lies in a third of the apex-distance of the diaphragmatic dome, the medial anterior border-line lies farther medially than to the right, the base of the lung is cut farther forward than to the right.* Both are propeller-shaped; the right one more pronouncedly so than the left.

*The curving to the left is more steep than to the right.

KLASON, T. (Stockholm). Radiological Methods for the Determination of the Conjugata Vera. (*Acta Radiol.*, 1922, i, Fasc. 3, 308–318.)

The procedure for the radiological measurement of the pelvis is given in the employment of the localization method of Mackenzie-Davidson. The method is based on the works of Manges, Runge & Gruenhagen, Guilbert, Léby-Solal, etc.

Two exposures are necessary. For the execution of the measurement the focus plate distance, the displacement and the orthoprojection of the focus on the plate must be known. These points are marked on the cassette holder by the help of a mirror arrangement with lead marks. For measurement, the plates are placed on each other in the same position as for their exposure, after which the images of the lead marks and the images of the end-point of the required diameter are drawn on tracing-paper. A stereoscope is then often necessary. These latter are to be connected with the focus-point appertaining hereto, and the distance of the point of intersection thus obtained gives the orthoprojection of the required diameter. The height of both end-points above the plate level must also be determined. By the base of the rectangular triangle that is formed from the focus, its orthoprojection and the image of the end-point, one knows the orthodiagraphic projection of the required point and has thereby all values that are necessary for the calculation of its height above the plate level. The lesser height is now deducted from the greater, and from the one end-point of the orthoprojection of the required diameter the figure obtained is recorded in cm. The distance between the point so obtained and the other end-point of the orthoprojection of the diameter gives the required diameter.

The conjugata vera of a symmetric pelvis can also be determined by a single exposure, if the orthoprojection of the middle line and the focus are noted on the plate (the focus laterally from the middle line). The determination takes place in a manner analogous to the previous one.

If during the exposure two metal rods are placed vertically on the plate level—one of them provided with a centimeter scale—the determination can be effected also through a construction, without knowing the focus plate distance and O-point (see further in the article).

By making lateral exposures of the pelvis, the author has, with the employment of sufficiently hard tube and careful development, obtained plates on which the symphysis as well as the promontory appear with satisfac-

tory distinctness. It was thus possible to determine the true conjugate of a symmetric pelvis, if the plate had been placed parallel with the sagittal level of the body, and the focus plate distance as well as the distance of the focus middle line were known.

PANNER, H. J. (Copenhagen). A Peculiar Characteristic Metatarsal Disease. (*Acta Radiol.*, 1922, i, Fasc. 3, 319–333.)

A metatarsal disease arising during the period of growth (at the age of ten to fourteen) is found which almost always is localized to the second metatarsal.

The disease falls into the category of diseases to which belong Calvé-Perthes's hip-disease, Koehler's disease in os naviculare pedis, Schlatter's disease in the tuberositas tibiae, and the spinal disease described by Scheuermann.

The primary starting point is the capitulum metatarsi, that is, as in the other cases, in an epiphysis; secondarily, arthritis deformans-like alterations may appear in the joint as well as thickenings of the diaphysis; often the last stage is, however, only a more or less marked deformation of the head of the joint itself.

The progress of the disease is mild, the symptoms not infrequently so slight as to be left quite unheeded, and a thorough treatment is but seldom necessary.

The changes are therefore frequently found only by an accidental roentgen-ray examination, and the latter gives (as is also the case in the above-mentioned disease) such characteristic pictures that the diagnosis will thereby be established.

BAASTRUP, CHR. I. (Copenhagen). Os vesalianum Tarsi and Fracture of Tuberositas Ossis Metatarsi V. (*Acta Radiol.*, 1922, i, Fasc. 3, 334–348.)

At the proximal extremity of the fifth metatarsal appear two forms with the likeness of epiphysis.

1. The "apophysis," a frequent, perhaps constant shell-formed epiphysis on the latero-plantar part of tuber. V. The ossification of it commences in the tendon of musc., peron. brevis.

2. The proximal part of tuber. V has now and then a certain independence showing a special centre for ossification. Occasionally a terminal form like an epiphysis may be seen, which at autopsy in the 3 cases hitherto examined has proved to be not an epiphysis but an independent bone: Os Vesalianum tarsi.

Tuberositas ossis metat. V corresponds morphologically, phylogenetically and ontologically to the vanished os tarsale V in the distal row, and os Vesal. must be understood as an atavically appearing os tarsale V.

The fact that os Vesal. is so seldom found, though more frequently than was formerly supposed, supports the supposition that os tarsale V disappears at an early stage in the development.

In further agreement with this theory is the fact that an os tarsale V is only found in toads, reptiles, and in the embryonic life of the lower class of mammals.

The theory is sustained by the mutual position of the bones in the early stages of the human embryonal life.

Now and then os Vesal. and the above-mentioned apophysis are mistaken for fracture of tuber. V. Several different circumstances in the anamnesis and in the roentgen-ray photos help to make the differential diagnosis.

The usually stated criterion for recognition of the genuine bones—that they are bilateral—cannot be maintained as a necessary claim.

WESTMAN, AXEL (Stockholm). Blood Changes by Roentgen and Radium Treatments. (*Acta Radiol.*, 1922, i, Fasc. 3, 349–357.)

The author has studied the blood changes in patients treated by roentgen-rays and radium. In both cases the changes are absolutely identical, only varying in degree according to the intensity of the irradiation. The changes of the red corpuscles are characterized by a slight increase in the number of erythrocytes as well as in the quantity of hemoglobin and the globular value, which are very differently expressed in the different patients, and which persist for a more or less lengthy period.

No certain conclusions can be drawn from these changes; they do not appear to be able to give any aid towards forming a prognosis. The changes of the white corpuscles are much more pronounced. After a few weak doses, corresponding approximately to a treatment for castration, an initial increase is obtained in the leucocyte count, caused by the neutrophile polynuclears, and on the fourth to the sixth day a decrease in the leucocytes occurs, followed by a slow retrogression towards the initial values. The leucocyte count remains constant. The changes in the blood, after the irradiation of tumors, belong to another type. By means of curves, it is shown how, after the irradiation by radium of uterine cancer, a transient increase of leucocytes is at first obtained and finally a decrease in the polynuclears and the leucocytes. At the end of but a few months, the blood-picture has returned

to its normal value. In the case of irradiations of mammary cancer after the operation, where there is no secondary toxic effect from the resorbed tumors, the initial increase of the leucocytes does not take place. The changes in the eosinophile blood-picture are attributed to a secondary toxic action proceeding from the tumescent resorption. The cases favorably influenced by the radiological treatment show much less marked blood changes immediately after the irradiations and a much more rapid repair, especially of the lymphocytes, than for the refractory cases. Consequently, the examinations of the blood may serve as a guide in respect to the prognosis.

HEYERDAHL, S. A. (Christiania). Treatment of Malignant Tumors with Radium Needles. (*Acta Radiol.*, 1922, i, Fasc. 3, 358–365.)

The previous favorable results of the treatment of malignant tumors with radium embedded in needles confirm what has also been experienced from other quarters. Embedded in the tissue of the tumor, the radium exercises throughout a much greater influence on the tumor than when applied on the outside, and it is also much more lenient towards the surrounding healthy tissue.

Tumors which had formerly been treated on the outside with radium, without any result, vanished after the embedment of radium in the tissue of the tumor.

As these observations have been made in rather a short time, they must, of course, be considered as quite preliminary.

LAEDERICH AND LEGOFF. A Case of Painful Gynecomastia Cured by Radiotherapy. (*Bull. et mém. Soc. Méd. des Hôp. de Par.*, May 18, 1922, xxxviii, 764.)

A vigorous man, seventy-seven years of age, a year before examination began to complain of extreme sensitiveness of the breasts, which had begun to enlarge in a lively fashion. Examination of his other organs gave negative results, especially the testicles. It is stated that this condition frequently follows disease of the testicles. After four radiotherapeutic applications given at weekly intervals to the right breast, it was found to have diminished notably in size; the spontaneous pains had disappeared, but the hyperesthesia to pressure and movements, although lessened, still persisted. The left breast had not altered during this time. Treatment with the roentgen rays was then administered to the left breast in a similar manner. The final result was all that could be desired, all the pains and inconveniences having disappeared, and the breasts having diminished in size almost to the normal.

J. T. C.

LOEPER, M. AND BAUMANN, J. The Action of Pepsin on the Motility of the Large Intestine. (*Bull. et mém. Soc. Méd. des Hôp. de Par.*, May 11, 1922, xxxviii, 726.)

To a certain number of patients with simple constipation (the dyschesic type of Hurst), the authors administered pepsin in subcutaneous injections of 20 cm. in solution in one c.c. of physiologic salt solution, after a preliminary control of the position of the large intestine by fluoroscopic observation twelve or thirteen hours after a barium meal. The effect of pepsin on the large intestine does not appear until after thirty to forty minutes and lasts only ten to twenty minutes. Intestinal peristalsis and muscular tonus of the bowel are excited, the effect being most marked in the cecum, ascending and right half of the transverse colon. Visible peristaltic movements are not seen, but there are very definite modifications of form indicating a temporary exaggeration of muscular tonus, manifested in some cases by a considerably more rapid evacuation of the cecum, in others by deeper and more numerous incisures in the transverse colon. The injections of peptone made under similar circumstances gave no appreciable effects. Patients suffering from so-called spastic constipation showed marked aggravation of this condition; whereas cases of atonic constipation with muscular and motor insufficiency exhibited definite acceleration of the intestinal transit. Untoward symptoms were nausea, and a tendency to vertigo and syncope. The pepsin probably acts through the vagus nerve. Many physiologists have admitted that the right colon is under the influence of the vagus nerve, and the experiment of Lebon and Aubourg in 1911 caused contractions of the ascending colon by excitation of the pneumogastric nerve.

J. T. C.

TERRY, WALLACE L. Radium Emanations in Exophthalmic Goiter. (*J. Am. M. Assn.*, July 1, 1922, lxxix, 1.)

The author and his associates at the University of California Hospital have treated 33 cases of extreme hyperthyroidism due to hyperplasia of the thyroid with the idea of converting them into better risks for major surgical procedures. No elaborate skin preparation is made. The operation is done at the office or at the bedside. For local anesthetic the author prefers to chill the sites selected with a small cotton sponge saturated with ethyl chloride.

Then the minute capillary tube containing the emanation is introduced into the gland by means of a small-caliber, hollow needle, and is pushed into place by a plunger. Usually six emanation tubes, containing a total of from 6 to 10 mc. are inserted in the upper, middle and lower thirds of each lobe and through one skin puncture on each side, the tubes being buried at least half a cm. in the thyroid. When the cases came to operation the author found that no adhesions were present, or that they were minute points where the needles had entered the gland. The adhesions were less than are found after ligation of an artery.

Results were checked in 16 of the cases. Fourteen were operated upon (resection) after intervals varying from thirty-two to one hundred and fourteen days after radium. Four of the 14 died from various causes. Ten are definitely cured after resection. In 2 cases there has been an apparent cure after radium alone. In one the basal metabolic rate was reduced in four months from 122 per cent plus to 12.9 per cent plus. In the other, the basal metabolic rate was reduced in four months from 84.4 per cent plus to 5.7 per cent plus.

The author considers radium contraindicated in the adenomas for the same reason that the roentgen ray should not be used, viz., the danger of producing atrophy of the thyroid gland proper and consequent hypothyroidism.

J. T. C.

HEYERDAHL, S. A. (Christiania). The Treatment of Myoma Uteri and Menorrhagia with Radium and Roentgen Rays. (*Acta Radiol.*, 1922, i, Fasc. 3, 366–371.)

Of 30 patients suffering from myoma uteri, 25 were exclusively treated with roentgen rays, and 5 were given combined roentgen-ray and radium treatment.

In 25 cases a good result was obtained: cessation of the menses together with complete or partial disappearance of myoma in most cases. Five patients were operated upon after the roentgen-ray treatment. Of 13 patients suffering from menorrhagia, 12 cases attained to a complete cessation of the menses. In one case there was a recurrence and later on an operation.

HOFFMAN, K. (Dresden). Appendicitis in Pregnancy. (*Arch. f. Gynaek.*, 1920, cxii, 230.)

The alleged displacement of the appendix by the gravid uterus is a subject which has caused much controversy, and Füth has claimed that in the latter months of gestation the cecum is forced well up in the abdominal cavity. This view has, in fact, been widely accepted, and the author after research is compelled to dissent from it. His roentgenograms show the cecum in normal position, making no unusual attempt to bring out the appendix. In one of his illustrations this organ appears naturally and is seen to hang down into the lesser pelvis. The 39 women whom he examined lay prone on the plate. He gave 100 gm. of barium sulphate mixed with 200 gm. of grits pulp. The earliest period at which the cecum became visible was six hours.

Diagrammatic sketches made from the plates show the positions of the cecum and fetal head and spine. The duration of gestation varied. The findings were as follows: In 86.5 per cent the cecum lay at a level below that of the iliac crest, while in 4 cases it was at the crest, and only once above. No relationship could be traced between the size of the uterus, tone of the abdominal wall and displacement of the cecum.

REINHARD, W. (Hamburg). Unique Case of Swallowed Foreign Body. (*Zentralbl. f. Chir.*, 1919, xlvi, 260.)

A man of twenty-two, in a suicidal attempt, swallowed a slender iron brace 22 cm. long by 2 cm. broad and 0.5 cm. thick. For two days he felt the weight of the object, which was 168 gm., but was not much incommoded, and ate as usual. At the end of this period the object evidently slipped into the small intestine, after which the patient complained much of colicky pain in the right hypochondrium with belching and nausea. The object could be plainly felt by the patient through the abdominal wall. There was at no time any intestinal obstruction, although pain persisted and diarrhea developed. Suddenly, the iron seemed to drop into the pelvis with the upper end to the left of the navel. The roentgenogram showed the object extending from the level of the left iliac crest obliquely to the right and into the pelvis. It was assumed that it was in the small intestine, wedged between the pelvis and the abdominal wall. It was removed by enterostomy, having been found in the lower part of the ileum near the cecum, evidently unable to pass the ileocecal valve. The author could find no case in literature of so long a body having travelled so far along the intestine. According to the older authorities, such objects have a strong tendency to remain in the stomach, but a recent analysis of 22 cases showed that the duodenum is the chief point of arrest because of its convoluted shape and its relative fixation. In order to make sure that there was no anomaly of the duodenum in his

patient, the author studied it on both screen and plate, finding nothing amiss.

BRINDEAU AND BOUSSIN (Paris). Roentgenography of the Placental Circulation. (*Gynécol. et obstétr.*, January, 1921, iii, 1.)

Roentgenography proved to be of great assistance in the demonstration of the finer vascularization of all the organs, and this is the case with the placental circulation. The injection solution must be very fluid and penetrating and must coagulate, which makes it necessary to inject it while warm. If hot melted double mercurial ointment is thrown into the vessels, coagulation at once follows, when the placenta is plunged into cold water. The specimen is then placed in formol for forty-eight hours. The freshly delivered placenta is taken before the blood can coagulate, and at once placed in warm water, when, by massage of the structure from the periphery toward the center (or rather the insertion of the cord) the blood is expelled from the latter. This act must be performed under water throughout; otherwise air-bubbles may enter. The blood-vessels are next flushed with warm water, using a syringe of 8 oz. capacity. The needle is blunt, and of the pattern of the trocar used for venous puncture. The cord is dissected to expose the mouth of one of the placental arteries, into which the needle-point is inserted and ligated. This operation is very delicate. The hot water is slowly injected and escapes from the other artery, forcing before it the residual blood. In certain cases, water also escapes by the placental vein. This phenomenon was never seen when the mercury was injected, and the latter could never be made to enter the venous circulation; nor if first injected into the vein could it be made to enter the arterial system. The water was injected until it came away quite clear.

The mercurial ointment was heated on a water-bath until quite fluid. The three parts of the syringe—metal barrel, rubber joining and nozzle—were all warmed, and the placenta itself with the cord was also warmed by immersion in warm water, the best temperature being about 60 C. The melted ointment was slowly thrown into one artery until it escaped by the other. This second or exit artery was then tied, and pressure applied by the piston to force the mercury into the finest ramifications of the capillaries. The venous system must necessarily be separately injected. The needle is inserted into the placental vein and the liquid forced in until resistance is encountered. It is less difficult to inject the venous system. When the process is completed, the vessels on the fetal surface of the placenta are seen to be turgescent. The cord is now tied tightly, the placenta washed on both sides and then plunged into a crystallizing dish filled with cold water; after thorough chilling it is placed in a 4 per cent formol solution. In injecting a number of placentas, some should have only the arterial system filled, others, only the venous and others, both systems. In the double injection specimens the effect is somewhat confusing. The authors have therefore tried to use barium or bismuth for one system and mercury for the other; without, however, much improvement. The older methods in which different colored wax was used may have had the greater merit in this respect. But in most of the specimens, the trained eye could distinguish between the two systems. Both sides of the placenta should be roentgenized. Sections made at various levels may also be plated, for the finer circulation is then visualized in a superior manner.

BINGEL, A. Encephalography. A Method for the Roentgenographic Demonstration for the Brain. (*Fortschr a. d. Geb. d. Rontgenstrahlen*, xxviii, 205.)

The author attempted to roentgenize the brain, without having any knowledge of the work of Dandy, who already in 1919 made intraspinal air injections in cases of brain disease. The author uses a lumbar puncture only with a stop-cock and a 10 c.c. record syringe. These instruments are connected by tight-fitting rubber tubes and by a T-shaped glass tube. The latter branches off to a rubber tube 60 cm. long to which a glass funnel is connected. The author injects, with the patient in the sitting position, 5 to 10 c.c. of air. The spinal fluid escapes by lowering of the funnel. The level of the spinal fluid is brought to its original pressure level. This method is represented until 40 to 60 c.c. of air have gotten into the spinal canal. It is of the highest importance that the pressure remains constant. The exposures are made with the patient in the horizontal position. Bingel saw in a case of gun-shot wound of the frontal portion of the brain, distention of the fissures; in a case of epilepsy, a very much distended left ventricle, which he attributed to scar formation in the cortex (later proved by operation); in a case of tuberculous meningitis, distention of the ventricles; finally, in a case of otogenous pachymeningitis, distention of the longitudinal fissure, disfigurement of the left ventricle and distention of the right anterior horn and of the left inferior cornu. The distention of the third ventricle and an encephalographic expression of

a choked disc, he considers respectively as optic neuritis. Out of 40 cases he has employed the American method in two, in which the injection of air through the lumbar puncture was unsuccessful. In several cases, especially in a case of meningitis of doubtful etiology, this procedure has had a favorable therapeutic result. In a case of meningitis, complete healing occurred.

JAENSCH. The Roentgen Appearance of Pneumokoniosis, Especially Its Coarse Form. (*Fortschr. a. d. Geb. d. Roentgenstrahlen*, xxviii, 299.)

The author calls attention to an unusual form of pneumoconiosis. In addition to the cases which present the usual net-like markings, mottling, circumscribed spot-like shadows, he also found, in 7 cases, tumor-like shadows and strand-like markings. The differential diagnosis from tumor could be made, although clinically to some extent, tumor suggested itself. Close study of the roentgenogram, the history and the slow development of the process were the deciding factors.

Metatarsal Pain. (*Fortschr. a. d. Geb. d. Roentgenstrahlen*, xxviii, 311.)

It is the author's opinion that, as a rule, sufficient attention is not paid to discomforts in the metatarsal portion of the feet (metatarsalgia) in cases of flat-foot, and that consequently they are not properly treated. In 30 cases, the author demonstrated roentgenologically changes in the first metatarsal phalangeal articulation (largest number); less frequently in the 2nd, 3rd and 5th (2 cases). Clinically, there was flat-foot or trauma. Roentgenologically, the changes correspond mostly to those of arthritis deformis. The changes at the second metatarsal bone were similar to those demonstrated by Köhler. At the 5th metatarsal bone, he always observed atrophic changes. While it was frequently assumed clinically that gout, tuberculosis or lues were present, the condition was, for the most part, hereditary. The roentgenological changes in the metatarsal bones seem of the utmost importance to the author, because one has to assume also the presence of changes in the adjacent parts of the joints (synovial bursæ, sheaths of tendons, muscles, nerves) and because of this the indications for therapy are given. It must be borne in mind, however, that the difference between roentgen-ray findings and the symptoms is often very marked. In early cases the roentgen-ray finding is often negative. As a therapeutic measure, the author recommends relieving the underlying cause, for which purpose well-fitting shoes, sufficiently high and broad in front, are necessary. Relief of the painful area may be secured by the application of devices for flat-foot, such as felt pads, excavated soles, occasionally even by tight bandaging of the metatarso-phalangeal area, massage, mechano-therapy and, in the most difficult cases, by operative procedure.

SGALITZER. The Roentgenologic Demonstration of Non-opaque Foreign Bodies in Empyema Cavities. (*Fortschr. a. d. Geb. d. Roentgenstrahlen*, xxviii, 332.)

An experimental test of 40 different small rubber drainage tubes demonstrated that a third were transparent to roentgen rays. Such drainage tubes, as well as gauze pads or sponges, which are frequently the cause of unexplained suppuration, may in empyema cavities be rendered visible by the *x*-rays, when these cavities are filled with opaque material. This opaque filling (bismuth vaseline, soluble tablets of circoniumoxide) may cling to the rubber tube or the sponge even after the contrast filling has been discharged from the empyema cavity. The foreign bodies then become visible, and may be removed with dressing forceps under *x*-ray control.

BROEMAN, C. J. Abstract of Paper on Radium. (*Kentucky M. J.*, June, 1922.)

Radium is the ideal treatment for all forms of basal-celled epithelioma and for prickle-celled epithelioma, if seen early enough, and no glandular involvement is present.

In carcinoma of the lip it is the treatment of choice when the case is seen early.

Radium is to be preferred in certain uncomplicated cases of uterine fibroid and bleeding.

Radium should be universally used in cancer of the cervix and inoperable cancer of the body of the uterus.

In all forms of inoperable cancer it relieves pain and hemorrhage and lessens discharge.

Radium is to be preferred to the *x*-ray in cases of goiter, because of its exact dosage, deeper penetration and ease of application.

It is the preferred treatment in tuberculous adenitis and vernal or spring catarrh, while in certain systemic diseases, such as splenomedullary leukemia, pernicious anemia, and Hodgkin's disease, radium therapy has proved beneficial.

In dermatology, radium improves and eradicates many heretofore stubborn and incurable conditions.

FREER, OTTO T. Radium Emanation in the Upper Air Passages as Compared to Radium; a Method of Applying it with Especial Reference to Laryngeal Carcinoma. (*Illinois M. J.*, August, 1921.)

Since November, 1919, the writer has used radium emanation instead of radium, with an extraordinary gain in efficiency, especially in carcinoma of the larynx. The great advantage lies in the very small bulk of the applicator for radium emanation. As much as 400 mc. may be applied in a very small container, whereas even 30 mg. of radium salt requires so large a container as to be impractical in throat work. Needles are the next best method, but are liable to cause deep sloughs, leading to severe hemorrhage; the pain following their use is severe; and patients often refuse to be needled, considering the procedure to be an operation. The apparatus used is a headband on which is a strong clamp for holding the laryngeal or pharyngeal tubular applicator ending in the screen. For the nose, simple wire applicators are fixed in small clamps attached to a headband. Silver or brass screens are used. The dosage used for carcinoma is 400 mc. hours in divided doses, repeated in six weeks. For papillomas, 150 mc. hours is enough.

L. S. GOIN.

KOHLMAN, WM. Radium in Carcinoma of the Uterus. (*Surg., Gynec. & Obst.*, August, 1921.)

The unsatisfactory results achieved by surgery in cancer of the uterus, particularly in cancer of the uterine cervix, are only too well known. The high mortality in even the most competent hands, and the complicating sequelae have brought the method into disfavor. The possibility of a new treatment, therefore, is welcomed. The palliative and even curative results of radium have been surprising, and give rise to these questions:

1. Whether radium should be applied only in inoperable carcinoma, and after surgery has failed;

2. Whether it should be used in assistance to surgery, as preoperative and postoperative radiation; or

3. Whether it should be given the preference.

In inoperable carcinoma, radium treatment is the treatment of choice. Preoperative radiation should have a distinct value. He who believes that postoperative radiation is advisable, is primarily a believer in radiation and that it destroys or checks the growth of malignant cells. The writer has used radium as the sole treatment in a number of cases, with gratifying results. The effect of radiation is noted clinically within a very few days. The writer, believing that a reduced blood supply and increased development of scar tissue are important factors in securing results with radium, has practiced ligation of the internal iliac and ovarian arteries, prior to, or simultaneously with radiation. In 12 cases thus treated, 5 were not benefited and died, 6 show primary cure, and one is living and unimproved. The writer has treated 96 cases of carcinoma of the uterus, 56 of them with radium alone. Nearly all were benefited. Those showing no improvement after one or two treatments were not, as a rule, benefited after prolonged treatment. Recurrences after clinical cure with radium occurred mostly in from six to nine months: most of these were very advanced cases.

The following table summarizes the results obtained in 96 cases:

Group 1. Carcinomata which are early and easily operable; (*a*) Cases treated with radium only. (*b*) Cases with panhysterectomy and postoperative radiation.

Group 2. Carcinomata that are doubtful and inoperable; (*a*) Cases treated with radium. (*b*) Cases treated with ligation and radium.

Group 3. Recurrence of carcinoma after panhysterectomy.

	Living	*Dead*	*No Report*	*Total*
Group 1:				
a.	4	1	1	6
b.	5	4	0	9
Group 2:				
a.	22	22	12	56
b.	7	5	0	12
Group 3:	4	4	5	13
				96

L. S. GOIN.

TAUSSIG, FRED J. In What Cases do Uterine Fibroids Still Require Operative Removal? (*J. Am. M. Assn.*, lxxvii, No. 5.)

The writer's opinions are based on three years' experience with radium, and a review of numerous reports from clinics here and abroad. Of 123 cases of uterine fibroids he operated on 87, and treated 36 with radium. The operative results were good in 82 cases; 2 cases developed phlebitis, and 2 died. The radium results were good in 32 cases; complications (nature unstated) occurred in 2 cases, and there were two failures. The dosage ranged from 800 to 1750 mg. hours, usually 75 mg. of radium were applied in the uterus, using silver and brass filtration, for sixteen hours. In 10 cases the radium was applied in the vaginal fornix instead of in the uterine cavity. He considers as contraindications to radiotherapy the following:

1. Fibroid larger than 12 cm. in its average diameter.

2. Submucous fibroids protruding through the cervix, subserous fibroids with a pedicle, cervical fibroids and intraligamentous fibroids.

3. Rapidly growing tumors, calcified fibroids, necrotic fibroids, and those complicated with malignancy.

4. Those cases in which a desire for children or for the preservation of menstruation make myomectomy or sub-total hysterectomy preferable.

5. Pyosalpinx and ovarian cysts, except small retention cysts.

A review of the literature shows a total of 1,099 cases of fibroid treated by radiotherapy by nine different men. A percentage of 95.5 of cures was obtained. L. S. GOIN.

FRANK, O., AND AMREICH, I., (Vienna). The Histological Changes Incident to Radium and *X*-Ray Treatment of Uterine Carcinoma. (*Surg., Gynec. & Obst.*, August, 1921.)

The writers have attempted, by means of serial sections of excised tissue, to learn the time of greatest action of radium or *x*-rays and the point at which their effects begin to lessen.

The radium treatments were given with 50 mg. of radium in a platinum or brass filter (thickness not stated) and 1 cm. of cotton and rubber, for twelve hours. This was repeated at intervals of one or two days for 5 treatments.

The *x*-ray treatment consisted of a dose of 18 H., using 3 ma., 11 Benoist penetration., 22 cm. skin distance, 3 mm., of brass, 0.5 mm. zinc, and wood or chamois four times as thick, forty minutes to each field. Eight or nine fields were covered, three or four in front, four behind and one perineal. The series was repeated after six weeks.

The same histological changes were observed after radium and after *x*-ray treatment. These were first, edema, then enlargement of the cells, carcinoma nest penetration of lymphocytes, vacuolization and hyaline changes. The first changes were noted on the third and fourth days. The influence of the rays was greatest between the fifth and seventh days. The rays were no longer effective after the fortieth day when the genoceptors of the cells became active and caused proliferation. They conclude that carcinoma cells respond more quickly to *x*-rays than to radium and do not show the stages marked by swelling of the cell body. They advise the use of the *x*-ray in treating the parametrium and the glands, and the use of radium in treatment of the carcinomatous crater. L. S. GOIN.

PETERSON, REUBEN. The *X*-Ray after the Inflation of the Pelvic Cavity with Carbon Dioxide Gas as an Aid to Obstetric and Gynecologic Diagnosis. (*Surg., Gynec. & Obst.*, August, 1921.)

Pelvic roentgenography has been the most helpful and interesting study the author has ever made. It has led to more careful diagnosis and to the study of diagnostic errors in order that similar mistakes might be avoided. Fewer exploratory operations are done than were performed before he began its use. He has inflated the pelvis 150 times with no bad effects. Both animal experiments and clinical experience have shown that there is no danger of injuring the intestines by the needle thrust, when the intestines are not adherent to the parietes.

There is some discomfort from the distension with gas, and patients may complain bitterly after the introduction of more than 1000 c.c. It is rarely necessary to use more. Chronic peritoneal adhesions increase the discomfort. The inflation should be conducted slowly. Carbon dioxide is used rather than oxygen because it is quickly absorbed. For transuterine inflation the gas is introduced at a pressure of not more than 200 mm. of mercury, as permeable tubes will permit the passage of the gas at this pressure. This method is contraindicated in patients with acute or subacute pelvic conditions, and in those past the menopause.

L. S. GOIN.

LACASSAGNE, ANTOINE. Experimental Researches on the Action of the Beta and Gamma Rays of Radium in the Tissues Following Radium-puncture. (*Journal de Radiologie et d'Electrologie*, v, No. 4.)

The advantages of radium-puncture are:

1. Utilization of the entire sphere of radiation, whereas treatments from the surface permit the utilization of less than half.

2. Direct contact with tissue to be treated, thus reducing to a minimum the loss of energy due to dispersion according to the law of inverse squares.

3. Relative safety from radiodermatitis.

The disadvantages are: the complications which may result from the opening of the tumor and the difficulty of maintaining in place over a considerable period the relatively large tubes which may be introduced. The substitution of radium emanation for radium removes most of these objections.

The factors which form the bases for rational radiotherapy are: the relative radio-sensibility of the tissues, the intensity of the radiation,

the duration of the application, and the total dose necessary and sufficient.

Dominici divides the rays of radium into two groups: The infrapenetrating, including all the alpha rays, most of the beta rays, and a few of the gamma rays; and the ultrapenetrating, including most of the gamma rays, and a few of the very hard beta rays. A lead screen 0.5 mm. thick is sufficient to arrest the infrapenetrating rays. One-half mm. of platinum will serve the same purpose, and Dominici advised this filtration even for intraneoplastic radiation. Recently, however, following the technique of Janeway, the tendency has been towards the utilization of all the beta and gamma rays.

The writer's experiments were carried out by the introduction of a glass tube 1 mm. long and 0.5 mm. in diameter, containing radium emanation, into the lumbar muscles of a rabbit at the level of the ovary. The distance from the radium emanation container to the ovary was known and constant. Under these conditions, muscular tissue being very slightly radiosensitive, the immediate effects will be those of caustic radiation, while the effects of the ovary will be due to selective cyto-causticity. The animals were killed, after varying periods of time, and the tissues were studied histologically.

The muscle tissue was found to have undergone a constant change in each case. On cross section the tube occupied the center of a circle, the limits of which were clearly defined, within which the muscle had become chalky white, homogeneous in aspect and firm in consistency. Its external limits were marked by hemorrhagic exudate. On longitudinal section the degenerated zone was seen to be a regular cylinder. Microscopically the general structure seemed to be preserved, but to have undergone a necrosis. The tissue stained weakly, all detail of its structure had disappeared, the cytoplasm had undergone a granular degeneration and the majority of the nuclei had disappeared. At the external limit of the zone the tissues stained normally. The transition from dead to living cells is very sudden without a transition stage. Beyond this point the capillaries are dilated and are full of blood and there is more or less interfascicular extravasation of blood. A little further from the zone the muscle is absolutely normal. The size of the area of necrosis depends somewhat on the amount of radiation. The necrotic cylinder is well formed after four and a half days. After twelve days the process is complete. After thirty days the necrotic cylinder is still characteristic and readily recognized. After two and a half months the cylinder is well recognizable but has undergone an appreciable diminution. After four and a half months the macroscopically visible lesion is very much reduced and has become a simple white area surrounded by scar tissue.

In one animal needles containing the same amount of emanation were introduced into the lumbar muscles, one on each side. One was extracted after twenty-four hours; the other was allowed to remain twelve days. The necrotic lesions produced had the same structure and were about equal in size. Several rabbits were killed fifteen days after radiation, lasting one, two, three, and seven days. The lesions produced did not differ markedly. The writer concludes from these experiments that the caustic action is most intense during the first few hours of radiation, and that it acts at a distance proportional directly to the strength of the tube, and, to a certain degree, independent of the total dose.

The following tables show the effect of filtration on the extent of the necrotic lesion:

a. Bare tubes.

Initial Value	Radius of the Lesion
0.70 mc.	1.5 mm.
1.25 mc.	1.8 mm.
2.30 mc.	3.5 mm.
6.00 mc.	5.0 mm.
8.00 mc.	6.0 mm.
16.00 mc.	7.0 mm.
26.00 mc.	8.0 mm.
35.00 mc.	8.5 mm.
48.00 mc.	8.5 mm.

b. Platinum needles 0.15 mm. thick.

Initial Value	Radius of the Lesion
1.5 mc.	0.0 mm.
3.0 mc.	1.5 mm.
5.0 mc.	2.0 mm.
7.0 mc.	3.5 mm.
9.0 mc.	4.0 mm.
12.0 mc.	5.0 mm.
20.0 mc.	6.0 mm.
35.0 mc.	7.0 mm.

c. Platinum needles 0.30 mm. thick.

Initial Value	Radius of the Lesion
7.0 mc.	0.0 mm.
9.0 mc.	1.8 mm.
12.0 mc.	3.0 mm.
20.0 mc.	4.5 mm.
28.0 mc.	5.5 mm.
38.0 mc.	7.0 mm.

d. Platinum needles 0.40 mm. thick.

Initial Value	Radius of the Lesion
8.0 mc.	0.0 mm.
8.5 mc.	0.7 mm.
12.0 mc.	2.5 mm.
18.0 mc.	4.0 mm.
26.0 mc.	5.5 mm.
42.0 mc.	6.8 mm.
48.0 mc.	7.0 mm.

e. Platinum containers 1 mm. thick.

Initial Value	Radius of the Lesion
10.0 mc.	1.0 mm.
16.0 mc.	1.5 mm.
20.0 mc.	2.2 mm.
34.0 mc.	5.0 mm.
45.0 mc.	7.0 mm.

It is noteworthy that the maximum radius of the lesion, with any amount of emanation and any degree of filtration, does not exceed 7 mm. except with the bare tube, the maximum with which is 8.5 mm.

The effects of radium on the ovaries have certain characteristics. They are selective, proportionate to the dose received, and independent of the amount of filtration.

The author concludes:

1. Radium-puncture by means of screened needles is preferable to that with bare tubes.

2. The initial value of a tube, filtered by a known thickness of platinum must not exceed that indicated in the tables as the maximum useful amount.

3. In order to attain the intensity necessary to destroy a tumor, the punctures must be multiplied, correctly placed with regard to each other.

4. For applications on the surface or in cavities by means of tubes of great intensity, the secondary filter must be at least as thick as the radius of the cylinder of necrosis resulting from a tube of such intensity.

L. S. Goin.

Pauchet, V. What the Radiologist should Communicate to the Surgeon and to the Physician in Regard to a Gastroenteritic Patient. (From Le due Costipazioni—the two types of constipation.) (*Policlin.*, 1922, xxix, 3.)

Ninety times out of a hundred, the radiologist's findings, even if he is very competent, are useless and insufficient. Such failure of the radiological examination does not depend on the radiologist *per se*, but upon the insufficiency of the demands put on him by the treating physician. The radiologist ought to furnish the following:

(*a*) How does the stomach function? Modifications of its form during evacuation.

(*b*) What is the diameter of the duodenum, and its mode of evacuation? The mode of evacuation is in accordance with the state of the duodenojejunal angle and with ileal stasis.

(*c*) How does the terminal ileum fill and empty? Is it dilated, angulated, thickened? Is it filled with a gross mass of barium and rapidly; or, on the contrary, by a normal quantity of bismuth? Does the mass of barium which remains in it stay 3, 5 or 18 hours?

(*d*) What are the conditions of the ceco-colon? Is the cecum distended, mobile, lowered, or deformed? When does it fill? Is it empty after 18, 24, 36 or 48 hours?

(*e*) State of the transverse colon. What is its shape? How much has it descended? What is its degree of kinking at an acute angle? Can the segments formed by this angle be isolated or not? Is there a double-barreled symphysis of the right and left halves of the transverse colon with the ascending or descending colons?

(*f*) What is the state of the sigmoid? Is it elongated, dilated, deformed? Are there diverticula? Is there megacolon? Dolico-colon?

(*g*) What is the aspect of the colon in its totality? Is it completely emptied in 48 hours? Are particular parts dilated, elongated or restricted?

The radiologist ought to administer an opaque meal and barium enema; both methods of examination are necessary.

In order that the examination should be complete, a radiography of the right flank will be necessary to see if there are any calculi in the kidneys or ureters, and if possible in the gall bladder; also the thorax should be examined to indicate the state of the mediastinal ganglia; the pressure or absence of ectasia, or aortic deformity, and the condition of the lungs.

The radiologist should instruct the patient not to take a purge or laxative nor mineral oil for the ten days preceding examination. The evacuatory clyster is indispensable.

Since these examinations are long and costly, it is not always possible for the radiologist to carry them out; however, it is indispensable that he should give these data to the surgeon:

(*a*) What is the state of the stomach?

(*b*) Does the terminal portion of the ileum fill in mass?

What time after the ingestion of the barium does it evacuate?

(*c*) In what time is the ceco-colon emptied?

(*d*) In what time is the large intestine completely evacuated?

TAECKEL AND SIPPEL. Concentration of the Roentgen Rays and Increase of the Dosis-Quotient by Means of Scattered Radiations. (*Müencben. med. Wcbnscbr.*, 1920, No. 20.)

The authors attempted to obtain an intensification of the direct radiation by means of scattered rays which attack the part laterally from the angle of incidence of the direct rays. For that purpose they used a water phantom 7 cm. high, with a surface measurement of 40 × 40 cm., in which a space of the size of the original area of radiation, 14 × 14 cm. or 8 × 8 cm. has been left opened. The scattered radiation of the water increases the depth dose of the central cone of rays. The surface dose is not increased, because the inner walls of the water phantom are covered with lead. The central field, therefore, is subjected to only the usual skin erythema dose, with the usual filter of 1 mm. copper. This is an advantage as compared to the ray collector of Chaoul, which is similarly constructed. The secondary irradiator, i.e., the water, is irradiated through a weaker filter, consequently there is no increase in the superficial dose, and no injury to the skin, but an increase of the depth dose by means of the secondary rays emanating from the water.

BLUMENTHAL. The Therapeutic Problem in Cases of Malignant Tumors. (*Deutscbe med. Wcbnscbr.*, 1921, No. 39.)

The author emphasizes the point that the malignancy of individual carcinomata depends not only upon the different biology of the cells, but also upon the resistance of the organism to the growth of the carcinoma. The statistics of operative results are unfavorable. The postoperative irradiation (e.g., in carcinoma of the breast) offers no guarantee against recurrences or metastases, but the poor results of postoperative radiation of carcinoma of the breast mentioned by Perthes and Payr may be explained by errors in technique. Just as other radiotherapeutists attempt to destroy the carcinomatous cells by means of the rays, but without greater injury to the normal tissues, he emphatically rejects treatments lasting several hours at one session (distance irradiation over large fields) because they are superfluous, not devoid of danger, and a torture to the patient. In order to increase the effect of the rays, Blumenthal recommends the attempt to cause an indirect effect by stimulation of the reactive processes of the organism, reactions such as Bier has produced in the tumor by means of the protein treatment (injections of caseosan). The author in addition also employs chemotherapy, using "Alival," which contains 63 per cent of iodine, by administering it intravenously or intramuscularly in doses of one to two c.c., three to six times a week. Alternately with "Alival" he employs arsenic (atoxyl in conjunction with sodium arsenate), which has no collateral effect, and Solarson strong. He considers futile the argument as to whether one should operate or irradiate because both are strong weapons. Neither solves the therapeutic carcinoma problem, because neither has more than a local effect. While Blumenthal generally would operate every operable case, he nevertheless varies his method occasionally; thus he did not operate an operable carcinoma of the breast in the male, but treated it with irradiation, iodine and arsenic, and cured it.

ANSCHUETZ AND HELLMANN. Results of Irradiation after Radical Operation for Carcinoma of the Breast. (*Müencben. med. Wcbnscbr.*, 1921, No. 32.)

A number of authors (e.g., Perthes and Payr) abandoned the postoperative treatment of breast carcinoma, because of the bad results. Even at this year's surgical and roentgenological congresses, there was a strong feeling against this postoperative radiation. The authors, however, have had favorable results; their statistics, which were collected critically and carefully, comprise 240 cases of carcinoma of the breast observed for from three to twelve years. In cases that were treated by operation only, there were, after three years, 49 per cent cures; after five years, 36.4 per cent; while with postoperative irradiated cases, there were 60 per cent and 55.5 per cent cures respectively. He ascribes the difference in his results as compared with those of other authors to his careful technique. He rays three fields, giving ⅔ of a skin erythema dose, through 3 to 4 mm. of aluminum, six to eight irradiations every four weeks, and then about three irradiations at eight-week intervals. (Haenisch of Hamburg has employed a similar technique with slightly increased doses, covering four or five fields. His results are approximately similar to those of Anschuetz. Haenisch will consequently continue to give postoperative radiations carefully in cases of carcinoma of the breast.)